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Guide for Local Area Population Projections

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Guide for Local Area Population Projections

by Richard Irwin

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Guide for Local Area Population Projections

1. INTRODUCTION

1.1 Description of Guide

This guide provides material with which to review, evaluate, and prepare projections for local areas. There are three main divisions: (1) a textual discussion of various aspects of projections for local areas, (2) supporting information, such as sources of basic data, a bibliography of pertinent literature, a brief glossary of technical terms, and a list of State agencies to assist in locating and obtaining population projections, and (3) a set of appendixes which provide statistical information useful in preparing population projections. A step-by-step description of one method illustrates the use of these materials.

1.2 Intended Use

The guide is intended to assist local planners in meeting their needs for population projections for the area in which they are interested. If the local planner for health, transportation, etc., finds population projections available, this guide provides assistance in identifying the methods used, in understanding their advantages and disadvantages, and in assessing their utility for the purpose at hand. This function is served by Sections 2 and 3, which review the general characteristics of projections for local areas and the more important methods now in use.

Section 4 is a guide to sources of basic data. Each demographic element which enters prominently in population projections is covered. Also included is a selected list of important data sources, and lists of State offices providing vital statistics and information on population estimates.

The references to pertinent literature in Section 5 will assist in obtaining further information and material, and a brief glossary covers the technical terms most commonly encountered.

The appendixes provide statistical information useful in preparing population projections for local areas. Projected national rates of fertility and mortality, and miscellaneous data not readily available in other publications are included. To illustrate the use of these materials, a simple version of the cohort-component method (see glossary for definition) is given in step-by-step format in Appendix H. The method presented is applicable to a county, group of counties, or other similar geographic subdivisions, and can be used to prepare population projections by age, sex, and race. An adjustment is introduced to take account of a postcensal population estimate, and a section describes the procedures required to adjust projections of subareas to a projection for a larger area, for example, the adjustment of county projections to agree with a metropolitan area total.

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2. GENERAL CHARACTERISTICS OF PROJECTIONS

Before moving on to the discussion of projections, it is necessary to distinguish clearly between projections and estimates. A population estimate is prepared by carrying forward the immediately preceding census count using actual data related to population change. An estimate is for a date in the past, and data series are used which relate directly to the period from the census to the estimate date.

Projections relate to the future and depend on the extension of trends without reference to actual data during the projection period.[1]

2.1 Projections, Forecasts, and Predictions

Anyone engaged in planning for some future action will want to consider the future conditions which will influence or be influenced by the action. If the planning directly involves the actions and needs of people, the future number and characteristics of the people become significant to the plan. As a first step, the planner may try to obtain a prediction of the future population. A prediction may be defined as an unequivocal statement about a future value or condition.

The most common response of demographers has been to produce population "projections." Projections have been defined as the numerical outcome of a set of assumptions made about future trends, usually (but not necessarily) selected with reference to trends of the past.[2] According to this definition, projections are conditional; they show what the population would be **if** these assumed trends actually were to occur. Alternative assumptions are often made to provide a range of outcomes, but once the assumptions are established, the calculations proceed without modification.

Some technicians use the word "forecast" to describe their work. This expression suggests that the figures are predictions, at least more so than projections. Projections, when contrasted with forecasts, are sometimes viewed as mechanical and unrealistic. In fact, only rarely are the assumptions for such projections established utterly without regard for the possibility that they might really come to pass. The element of judgment enters in the choice of the projection method and in the determination of the assumptions. If alternative assumptions are made to provide a range of outcomes, the extent of the range indicated implies judgment in choosing the limits. The distinction between projections and forecasts therefore cannot be made with absolute precision, and in this guide the term "projection" is used as a general descriptive term, but in a broad sense which does not exclude the exercise of judgment in the projection process.

2.2 The Functional Value and Use of Projections

Whatever the terminology, the user simply wants to know what the future population will be. Since there is usually some uncertainty as to future developments relating to the action being planned for, users want to eliminate the element of doubt as to the future population. Even the introduction of a confidence interval, which has been suggested as a solution to the problem,[3] would not completely satisfy them. They would like a prediction.

Population projections have not been very successful as predictions. From the failure of demographers to foresee the long post-World War II "baby boom," on down to the failure to predict the recent shift in migration patterns resulting in slower growth for large metropolitan areas, the record has not been impressive. What should be the reaction of users to this?

Obviously they will need to review carefully any projections to be used. There are two phases to this review, the evaluation of the method used, and of the specific assumptions established within the framework of the method. These are clearly spelled out in a well prepared set of projections, with enough detail for the user to identify the significant

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[1] It is possible to make "projections" for some date in the past by imitating the conditions that would have existed at some past time, but this would probably be done for purposes of evaluation.

[2] For a more extensive discussion of these concepts, see Nathan Keyfitz, "On Future Population." **Journal of the American Statistical Association**, Vol. 67, No. 338, pp. 347-63. June 1972; and Denis F. Johnston, "Long Range Projections of Labor Force." **Proceedings of the Second Syposium on Long-Range Forecasting and Planning,** Alamogordo, New Mexico: U.S. Department of the Air Force, October 1967.

[3] Keyfitz, ibid., p. 356, undeı "User's Loss Function."

factors which control the numerical outcome of the entire procedure. Alternative assumptions of the future trends of key elements are very desirable, as users are provided with a range of outcomes. If the element of judgment entered, the reasoning and basis for the judgments made should be clearly shown along with some idea of the influence of these decisions on the projections themselves.

The clear exposition of assumptions and method makes it possible for users to form some opinion as to the probability of error, and to evaluate the utility of the projections for their own projects. The user would still prefer a prediction but must learn to live with uncertainty, at least for the present. Yet even though the probability of accuracy cannot be very precisely determined, projections can serve a useful purpose in three ways: (1) charting a future course, (2) monitoring change, and (3) improving the judgment of both those who use and those who prepare the projections.[4]

2.21 **Charting the future.** Projections can be useful in charting a future course, and in preparing for eventualities which may affect that course. For example, a projection may serve as an advance warning of an otherwise unexpected development. In some cases, the intent may be for the projections to be wrong, that is, it is hoped that the projections themselves will trigger countermeasures to prevent their coming to pass.

As mentioned above, an important resource is the preparation of alternate projection series with differing assumptions. In a population projection by the component method, births, deaths, and migration are projected separately. One can first project each of these components based on the trends of the past. Economic factors can be introduced in a more complex application. By making alternative assumptions it is possible to chart the effect of an unexpected change in each component, and to observe the impact on the projected values. This is often done for births and migration. As to mortality, it has been common to make only one assumption, since death rates have been relatively stable over the past 20 years. If, however, the aged population is the subject of study, it may be advisable to make alternative mortality assumptions. The projected populations under the alternative assumptions quantify the impact of variation in the basic rates and provide an insight into the possible effect of unexpected change.

2.22 **Monitoring change.** The projections can serve another useful function even when not successfully predicting the actual future population. They provide a yardstick against which to measure change. Does a given change during a particular time period in one of the demographic or economic factors directly affecting population growth represent a deviation from past trends? The answer is not always obvious. At the present time, an increase in the number of births does not necessarily represent an increase in the birth rate, as the number of women in the childbearing ages is increasing due to fluctuations in the number of births in previous years. Moreover, an increased in-migration of persons of retirement age may not increase the population very much due to the high death rates at advanced ages.

If the current change of elements like those just cited is compared with projections previously prepared, based on past trends, the degree to which the new data represent a deviation from trend is easier to determine. Any set of projections should be monitored in this way and definitely should be revised if current data depart significantly from the course charted by the previous calculation. Many technicians recommend an automatic annual revision if only to take a new postcensal estimate into account.

2.23 **Improving judgment.** Both the actual preparation and the critical review of projections contribute to improved judgment on the part of the user. Monitoring change is not the exclusive domain of the demographer; neither is the preparation of projections. A number of simple techniques have been developed, one of which is presented in Appendix H of this guide. The actual preparation of projections serves an educational function by directing attention to dynamic factors which will exert an impact on future developments. The choice of assumptions forces one to look carefully at available information, and contributes to a better understanding of the projection process.

2.3 General considerations

There are some factors of such general application in evaluating local population projections that they are almost axiomatic. These relate to the size of area, time span of the projections, and complexity of the method used. Other pertinent factors are the presence of special populations (military, college),

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[4] For a more complete discussion of some of the concepts in this and the following sections, see Peter Morrison, "Overview of Population Forecasting for Small Areas." Paper presented at the Conference on Population Forecasting for Small Areas. Oak Ridge, Tennessee: Oak Ridge Population Research Institute, June 1975. For a review of the Uses of Projections, see Johnston, op. cit.

the impact of government decisions on local population change, the function of postcensal population estimates, the time unit used in the model, and census undercount.

2.31 **Effect of area size and time span on accuracy.** In general, the smaller the area, the greater the error to be expected. If we assume that a certain percent error may be expected for national projections, we would expect at least this error for a smaller area, plus any deviation of the area from national trends. Migration is an outstanding example. At the national level, immigration is a relatively stable component of national population change, being controlled by law.[5] At the local level, however, migration is a large and variable element in population change. Even for a market area, such as a standard metropolitan statistical area (SMSA), the rate of net migration can be high. The Tampa-St. Petersburg, Florida SMSA had a net in-migration of 26 percent from 1970 to 1975. A reversal in the direction of net flow can also occur, as in the case of the Los Angeles SMSA, which has experienced net out-migration since 1970 after a long period of net in-migration.

Within a market area, the rate of net migration for the constituent counties may vary and greatly exceed the net migration rate for the area as a whole. From 1970 to 1975, the Atlanta SMSA experienced a net in-migration of 7 percent, but Fulton county (which contains the city of Atlanta) had a net out-migration of 7 percent while Gwinnett county had a 50 percent net in-migration. Substantial variation in net migration rates is also observed among the various age groups of a county. In one age group there may be a heavy net flow from one county to another within a metropolitan area, while in another age group the direction in reversed for the same pair of counties.[6]

Elements other than migration also vary from place to place, such as birth and death rates, employment opportunity, income, and governmental policies, to mention a few that affect population change.

Size of area in the context of this section can be taken to mean either geographic or population size. If the geographic area is small, then a short distance move may take a person into or out of an area, and migration rates will be high. If the population is small, then an event involving relatively few people, such as a small increase in employment opportunity, might have a large impact on the rate of population change.

A word of caution is in order in working with counties. United States counties vary a great deal in population size, land area, and degree of urbanization. Some have urban populations in the millions, while others have small, completely rural populations. In between are counties with mixtures of urban and rural. These considerations must always be kept in mind in reviewing or preparing projections, since they can affect the reliability of the projected values.

With respect to time span, the further into the future the projections are carried, the greater the error probably will be. Technicians preparing projections are generally aware of this limitation, but users request local area projections for as far as 50 years ahead. These requests may be perfectly legitimate. In planning for a capital expenditure with a long useful life, such as a hospital, bridge, or dam, the size of the population far in the future is of central importance.

Projections that far ahead are being made for local areas such as counties and even census tracts, but the user should be given some idea of the likely error inherent in such projections. Unfortunately, such an evaluation is not now possible. More studies are needed as to the accuracy of projections for local areas, especially over a long time span.

Even in the very short run, projections for States have differed substantially from recent current population estimates. A study comparing three sets of projections for States (with a base date of 1970) with the 1973 postcensal estimates indicated an average deviation of about 2.6 percent for the 3-year period.[7] This deviation does not appear excessive, but taken as a percent of population change the errors were much larger. The projections analyzed had been prepared by the U.S. Bureau of the Census, the U.S. Bureau of Economic Analysis, and the National Planning Association.

An earlier set of State projections for 1970 published by the Bureau of the Census was more

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[5] The recent immigration of refugees from Vietnam shows that "stability" is subject to change. Illegal immigration may also be significant.

[6] See Section 3.234 under Adjacent cohort technique for a further discussion of rates by age, and section 3.235 under Geographical reference unit, for additional comments on area size as it relates to the cohort-component method.

[7] David J. Bjornstad, Clifford H. Patrick, and Kathryn P. Nelson, "State Population Projections: A comparative Review of National Series and Their Practical Usefulness," **Report No. ORNL-UR-120.** Oak Ridge, Tennessee: The Oak Ridge National Research Laboratory, 1974.

satisfactory, considering the time span. The projections started from 1960, using migration trends for the period 1955-60 with an adjustment for the 1965 postcensal estimate, and had an average error of 2.9 percent for the low fertility assumption, with no error over 11 percent. For the high fertility assumption the average deviation was 3.1 percent.

For counties, one would expect larger errors. One study for North Carolina counties indicated errors of 15 percent or over for 8 of 100 counties for a 10-year period, with an average error of 7 percent.[8] For a similar set of projections over the same time period for Oregon counties, 14 of 35 counties had errors of 15 percent or more, with an average error of 12 percent.[9]

These studies show that even in the relatively short term, substantial errors are possible. A long period of experience and testing will be required before the accuracy of local population projections can be estimated, especially for longer time periods.

2.32 **Complexity of method.** Although it has not been demonstrated, it is often taken for granted that the more complex the method, the more accurate the projection. This is probably true up to a point. In addition, increased refinement can bring benefits other than simply higher accuracy of the projected total population. The detail may be useful in itself or it may contribute to a better understanding of the projections.[10]

If the projections are by component (see glossary for a definition) they can also be more meaningfully monitored against current estimates, by evaluating each component separately. In addition, the component projections should be more accurate, since some of the critical factors can be more closely studied. For example, migration for the local area can be isolated, and additional variables related to it, such as employment opportunity and income levels. Other variables sometimes considered are unemployment rates, climate, educational attainment, and labor force participation rates.

However, complexity does not guarantee accuracy, and greatly increased detail can contribute to lack of control of the projection process, and difficulty in understanding the results. Future values must usually be projected for each variable that is identified, and these additional projections introduce a new element of uncertainty. The more variables, the larger the data base required, and the more time-consuming it is to review and monitor the projections. The technician and the user should work towards a balance between the simple and the complex suitable to the particular project at hand. The main point to be emphasized is that simple applications should not automatically be rejected, as complexity introduces problems, although it also brings advantages.

2.33 **Special populations.** Military installations, colleges, and institutions create difficulties for population projection models. The expansion and contraction of these special populations do not necessarily parallel general population trends for the local area. The special population may appear or disappear suddenly, and the size of the group may be a larger proportion of the total population. Thus, any projected trend may be sharply contradicted by an unanticipated change in the special population.

In addition, many of the special groups are composed of persons within a very narrow age range. In these ages their relative share of total population will be even larger. If the projections are by age, the projected age distribution can easily become seriously distorted, and careful review is required.

Perhaps the most volatile group is the military. Station strength increases and decreases suddenly, and closing of a base is not uncommon. If the closure occurs during a period used as a basis for projecting a future trend, the projection model will implicitly "close" the base again, each time the projection cycle is repeated. This can occur whether the base period statistics involved are demographic, economic, or social in type. In recent years, the overall numerical strength of the military has been decreasing, and the expected future size of an installation should be taken into account in a projection model, if possible. Station strength figures are usually easy to obtain, and formal projections of future strength are sometimes available. Age statistics are more difficult to obtain.

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[8] Unpublished study by Carl Peter Swenson. "Test of Projection Method Using 1950 and 1960 Census Data to Project to 1970." Raleigh, North Carolina: Department of Administration, State of North Carolina, 1974.

[9] Oregon State Board of Census, "Zero Net Interstate Migration Projections for Counties and Economic Areas by Age and Sex, State of Oregon: 1960-80," **Population Bulletin No. P-9.** Portland, Oregon: Portland State College, 1963. One county is excluded from this comparison because a special adjustment to its migration rate was introduced. County migration trends 1960-70 were adjusted to produce zero net interstate migration, which in this case is a realistic assumption.

[10] See Section 3.235 under Level of detail for additional comments in the context of cohort-component projections.

ce a large proportion of the military population n the range from 18 to 30 years of age with a od deal of variation in the distribution within this group from base to base, it is important to tain accurate data. Statistics for dependents are difficult to obtain, yet a correction for these uld be included in an adjustment for military ulation. One study indicated 1.4 dependents per itary person.[11]

Colleges pose problems similar to military installons in that the age range is restricted, and change enrollment is partly the result of administrative cisions. These decisions are responses to conions not necessarily related to the local area's wth characteristics. Since World War II, college ollment has expanded rapidly, new schools have eared, and small ones (often former teachers' leges) have grown. At present, enrollment has eled off at the national level, but many individual ools continue to change rapidly. As with the itary population, if such changes occur in a base iod which serves to establish a projected trend, projections may be very unrealistic. A problem culiar to the college population is that enrollment nge may or may not mean a migratory movent of students. For example, the current large rease in adult enrollment can create a false pression of population change if the statistics are t carefully monitored.

Institutions such as mental hospitals, sanatoriums, d detention facilities are somewhat less prone to id change in size, and the age range is not always restrictive as with the college and military ulation. Similar problems arise, however, and uld not be overlooked.

In dealing with special populations in projection dels, it is best to distinguish clearly between the cial population and the general population for all evant statistics, and to project the two groups lependently. If the trend of some historical period involved, either for demographic or economic tistics, then the effect of the special population st be removed.

This is not always possible and independent ojections of the special population may not be sible. Some simpler technique is then indicated, ch as adjusting the projected total population in cord with the expected future divergence of the trend of the special population from the trend of the past.

[11] Richard B. Halley and Morton Paglin. "Population recast, State of Oregon and Economic Areas: 1960-1985." tland, Oregon: Oregon State Board of Census, Portland te College, p. 11, 1964.

2.34 Postcensal estimates. During the past 15 years the quality and volume of postcensal population estimates have increased significantly. In addition to estimates for States, there are annual published estimates for counties through the Federal-State Cooperative Program for Local Population Estimates.[12] The Census Bureau has developed a new series of estimates for 38,000 administrative jurisdictions for use in the Federal General Revenue Sharing program. Estimates for 1973 have been published, and a set for 1975 will be completed early in 1977.

The postcensal estimate can be used to monitor the projections by regularly comparing the estimate with the projected trend. This becomes progressively more important as the length of time since the last census increases. If the estimate deviates substantially from the projected trend, the projections should be adjusted.

There are two basic approaches in making this adjustment. One is to establish a new benchmark population figure by age and sex on the postcensal date and begin the first projection cycle from that date. Another is to "pass through" the population estimate, retaining the original projection dates, but adjusting the trend of the projection to account for the difference observed at the postcensal estimate date. This is the approach illustrated in the step-by-step procedure in Appendix H. The degree to which the difference between the postcensal estimate and the projected trend is allowed to influence the trend of future projections can be varied according to the analyst's confidence in the accuracy of the postcensal estimates, and the expected permanence of the new trend.

Operationally, the adjustment required by the postcensal estimate is most conveniently made by changing the migration component, although if projected birth and death data do not match with subsequent experience, they too can be adjusted.

2.35 Time Unit. Projections are usually prepared by 5- or 10-year units of time, repeating the projection cycle as many times as needed to reach the target date. If the projections are by age, the size of the age groups used is a limiting factor to the choice of the time unit, since this unit must either

[12] See Exhibit 4-C, p. 40, for a list of the agencies cooperating in the program.

match exactly the size of the age group, or be an even multiple thereof. For example, if 5-year age groups are being used, the time unit can be 5 years or 10 years, etc. Projections are sometime carried out for single years of time by single years of age.

If a comparison between decennial census data is involved, there is some advantage in using a 10-year projection time unit, as the intercensal change of the variables included in the model need not be subdivided. For example, a serious error is involved in estimating net migration by the residual method for 5-year units of time and age from census data ten years apart, as described below in Section 3.234 under Adjacent cohort technique. The problem does not materialize when census data on gross migration for 5-year periods of time are used.

The choice of time unit depends on the character of available data, the total time span covered by the projections, the intermediate dates for which projections are desired, and the amount of data required by the project. Note that interpolation is an alternative for obtaining figures for dates within the projected time span.

2.36 **Census undercount.** The desire to adjust local population statistics for census undercount is often expressed. Estimates of net census undercount at the national level show sharp differentials by age, race, and sex, with high rates for some groups, notably young adult Black males.

However, there are no reliable estimates of undercount below the national level, and it is reasonable to suppose that there is much variation in rates from one locality to another. The use of nationally derived rates to adjust local area statistics, therefore, does not necessarily improve the accuracy of the data. Futhermore, the national estimates are available only by age, sex, and race. For any other characteristic which might enter into a project, such as income and family status, there are no estimates of any kind, although these factors may influence rates of net census undercount. It therefore may be just as accurate, and is certainly a great deal simpler, to carry out all computations using unadjusted census level statistics.

It is possible in local projections, however, to take limited account of undercount in the estimates and projections of net migration by age through the use of national census survival rates (NCSR) in place of life table survival rates (LTSR).[13] Tables of NCSR's suitable for use in cohort-component projections are presented in Appendix B of this guide.

Projections using census survival rates are still at "census level"; their use only adjusts for the difference in undercount (at the national level) of an age cohort in two successive censuses, carried out separately for each race-sex group if desired.[14]

2.37 **Administrative decisions and government policy.** There are many ways that actions by governmental units influence population change. The decisions regarding military installations, colleges, and institutions are only one type of such actions, although they perhaps have the most direct impact on population change. There are many other governmental actions, some very broad and general in impact, others very specific as to locality, which influence the pattern and extent of local population change.

As to general influences, the impact of government programs for highway construction and housing is not always recognized. These programs have supported the pattern of suburban development since World War II. The huge sums spent on highway construction made it easier for tens of millions of Americans to live ever further from the central city. Another large subsidy to suburbanization is the complex of government programs supporting the financing of housing construction. Both of these programs are still in force, but in some communities, other forces influencing the extent of suburban development have increased in relative importance. In many of the larger metropolitan areas, the increasing costs of land, construction, financing, and transportation have driven up the cost of suburban living, resulting in more construction of townhouses and apartments, in some cases moving towards the city center from the periphery of suburban development. The complex interaction of these changing values will affect local population growth in the future.

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[13] For a discussion of the use of NCSR's in projections, see Section 3.233 under National census survival rates.

[14] Note, however, that local differences in net census undercount by age, race, and sex are implicitly taken into account if residual estimates of past net migration rates are assumed to continue into the future, whether these estimates were derived using LTSR's or NCSR's. This assumption is illustrated in the projection shown step by step in Appendix H. For a detailed discussion of this factor, see Richard Irwin, "National Census Survival Rates in Population Projections for Local Areas." Paper presented at the 1976 Annual Meeting of the Population Association of America, Montreal, Canada.

In a much more specific sense, State and local government policy can decisively influence population change. By regulating residential construction through zoning restrictions, issuance of building permits, and construction for water and sewage, population growth can be encouraged, or if desired, practically stopped. While zoning restrictions have often been overthrown by the forces favoring residential development, in recent years restrictive policies in the granting of building permits and sewer construction have had decisive effects in limiting population growth in some cases. In one large suburban county a building permit moratorium was an important factor in the reduction of the previous high rate of net migration to zero within a few years.[15]

In one middle-sized city an ordinance was passed in 1972 establishing a population growth policy which links population growth to the expansion of facilities for education, water supply, and sewage disposal. This ordinance places an annual limit on the number of new housing units having five or more units in a subdivision or in a structure.[16] There was a challenge in the courts, and the appellate decision which supported the ordinance will stand, as the Supreme Court refused to review it. In a neighboring county, a population policy is being established with the intent of providing for orderly population growth by linking growth to the expansion of water and other needed facilities.[17]

The actions by these three jurisdictions are symptomatic of a somewhat new attitude toward controlling population growth on the part of some local jurisdictions. Other manifestations of this attitude are zoning regulations imposing a very low population density, and policies restricting the establishment of new industries if they pose a threat to the physical or social environment. This new indifference to economic growth is exemplified by the recent refusal of the State of Colorado to pursue the promised economic benefits of the 1976 Winter Olympics. These attitudes seem to be spreading, and the future population of many local areas will be influenced by the outcome of conflicts between the proponents of population growth and those wanting to restrict it.

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[15] Prince Georges County, Md. The capacity of existing sewage treatment facilities necessitated a moratorium on building beginning about May 1970. In some parts of the county, residential construction almost stopped, and in others was greatly reduced.

[16] Petaluma city, Calif. An annual limit of 500 housing units in multi-unit structures is enforced with a maximum of 100 units for any one parcel of land. Construction with four units or less in the structure, or on single lots, is not affected by the ordinance.

[17] Marin County, Calif. Beginning in 1972 the electorate had twice turned down bills relating to expanded water supply capacity. In 1973 a county-wide plan was adopted for implementing a growth policy.

3. PROJECTION METHODOLOGY CURRENTLY IN USE

3.1 Introduction

The most striking feature of the current scene in local area projections is the sheer volume of activity. State agencies, city and metropolitan planners, health planners, federal agencies, universities, private corporations—all are producing projections for various classifications of local areas, using a wide variety of methods. In a systematic survey taken in North Carolina,[1] it was found that five organizations had produced complete sets of projections for the counties of that State. One set was prepared by a private company, one by a university-related organization, two by different State agencies, and a fifth by a research institute. Add to this the projections for metropolitan areas by two federal agencies (Bureau of Economic Analysis and Bureau of the Census) and the miscellaneous projections by local planners for their own areas, and the collection becomes large, indeed. Although there are an unusually large number of projections available for areas in North Carolina, in other States two or three alternative sets of projections are typically available for metropolitan areas and their constituent counties. These projections are produced by a variety of new methods and modifications of old ones. It is not surprising that the respondents in the North Carolina survey indicated a strong concensus on the need for "uniform, single source estimates and projections."[2]

The variety of methods now in use is greater than it was a few years ago, and there is increased use of the more sophisticated methods. In 1969 the Bureau of the Census prepared a bibliography of population projections for States and local areas. Of the 246 publications reviewed, only 34 used the cohort-component technique to develop age detail. The Bureau has begun updating this bibliography, and initial results indicate much greater use of this method as well as greater variation in its application, especially for the migration component.

The geographic detail given in population projections has also increased. Twenty years ago there was little attention given to projecting the population of census tracts. One analyst wrote, "I.......shall consider a 'small area' a specific geographic subdivision of the country such as a region, State, subregion, metropolitan area or district, county, or city."[3] Today one often hears of projections for census tracts or even smaller areas.

The quality of available projections varies a great deal. Much published work is well thought out and shows an awareness of basic problems. For example, adjustments for shifts in college and military populations are not unusual, and adjustments for a postcensal estimate are also done. It is hoped that in the future some concensus and standardization of methodology will emerge from the present extensive experimentation.

3.2 Methodology for Projections of the Population of Local Areas

There are five broad categories into which most projections can be placed: (1) mathematical extrapolation, (2) ratio, (3) cohort-component, (4) economic base, and (5) land use. These might better be termed procedures than methods, because there is much variation in the manner in which they are applied. We will stay with the traditional nomenclature which refers to these categories as methods, even though current applications frequently use more than one and might be called "methods" in their own right. A linking of economic-based projections with the cohort-component technique is one of these cases.

In spite of this interaction between categories, it will still be useful to consider each in turn.

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[1] Harry M. Rosenberg, "North Carolina Demographic Data Needs and Capabilities: Survey Results." **Proceedings of the North Carolina Demographic Data Workshop**, Chapel Hill, North Carolina: Carolina Population Center, University of North Carolina, pp. 26-38, 1974

[2] Ibid., p. 35.

[3] Jacob S. Siegel, "Forecasting the Population of Small Areas," **Land Economics**, Vol. 10, No. 1, pp.72-87, Feb. 1953.

3.21 Mathematical extrapolation. The simplest and quickest way to obtain a projected population figure is to extrapolate along some kind of mathematical curve. This method is not generally held in very high regard, but if only a rough approximation is required, without detail by age and sex, a mathematical extrapolation may be useful. Straight lines and geometric and logistic curves are used to extend a population trend of the past into the future. Sometimes a least-squares line is passed through the known data points of the past.[4] Intuitively, the logistic curve is best suited to population growth, yet few actual uses are on record. In one test, the use of the Gompertz curve, similar to the logistic curve, did not produce satisfactory results on New Jersey counties.[5]

The most common form of mathematical extrapolation is the extension of an historical rate of growth for the total population into the future. A simple illustration of such an extrapolation is shown in figure 1 for "Exurban County, USA".[6] The total population of the county on July 1, 1960 was 24,580 and in 1970 was 32,499. On the simple assumption that the amount of change for 1960-70 will be repeated in 1970-80, the 1980 population is projected to be 40,418. This is shown in figure 1 as the "arithmetic projection." It can also be assumed that the 1960-70 rate of population change will be repeated in the succeeding decade. This assumption gives a projection of 42,969 which is shown in figure 1 as the "geometric projection."[7] Obviously, some base period other than 1960-70 could be selected, and the projected numbers might be very different.

A postcensal estimate can be consulted in order to evaluate the projections. On July 1, 1974 such an estimate for this county was 41,700, which is considerably higher than any of the projected trends. The estimate is shown in figure 1 by an "*." In the light of this estimate, the preliminary 1980 projections should be re-evaluated.

A large scale application of mathematical extrapolation can become quite complex, like those offered by a team at Rutgers University for doing large sets of projections for minor civil divisions.[8] Three models are given, which in essence project rates of population growth, setting maximum and minimum allowable limits. After calculating projections for all parts of the whole, the results are adjusted pro-rata to a previously determined control total.

The Rutgers group offers another technique originally proposed by Newling.[9] It could be called a mathematical extrapolation, but since it introduces a population density function, it will be discussed later in Section 3.25, Land use methods.

In general, mathematical extrapolations can lead to unreasonable population projections, especially if carried far into the future. In any group of subareas, some grow faster than others. The common assumption that a rate of growth will continue in the future results in the fast-growing areas receiving larger and larger population gains, becoming unrealistic in terms of the implied migration that is necessary to effect the population shift.

There are many uses of mathematical extrapolation in projection models other than just projecting the total population of an area. Subsets of the model, such as survival rates, the number of persons per household, or labor force participation rates, may need to be projected into the future. Extrapolation is a standard technique. For example, in projecting labor force participation rates, the trend of the past might be noted and this trend extrapolated into the future.

Regression technique, as used in population projection models, can be thought of as a sophisticated means of extrapolating a trend; the expected

[4] Research Triangle Regional Planning Commission. "Population and Urban Land Use Projections, Research Triangle Region of North Carolina." Research Triangle Park: North Carolina, 1969.

[5] Bruce E. Newling, "Population Projections for New Jersey to 2000." New York: The City College of New York, p.1, 1968.

[6] "Exurban County, USA" is a fictitious name for an actual United States county used in Appendix H to illustrate projection techniques. For a discussion of the characteristics of the county see Appendix H, Section 5.1.

[7] The preliminary projection by the cohort-component procedure illustrated in Appendix H gives a 1980 population of 45,105 as shown in table H-10.

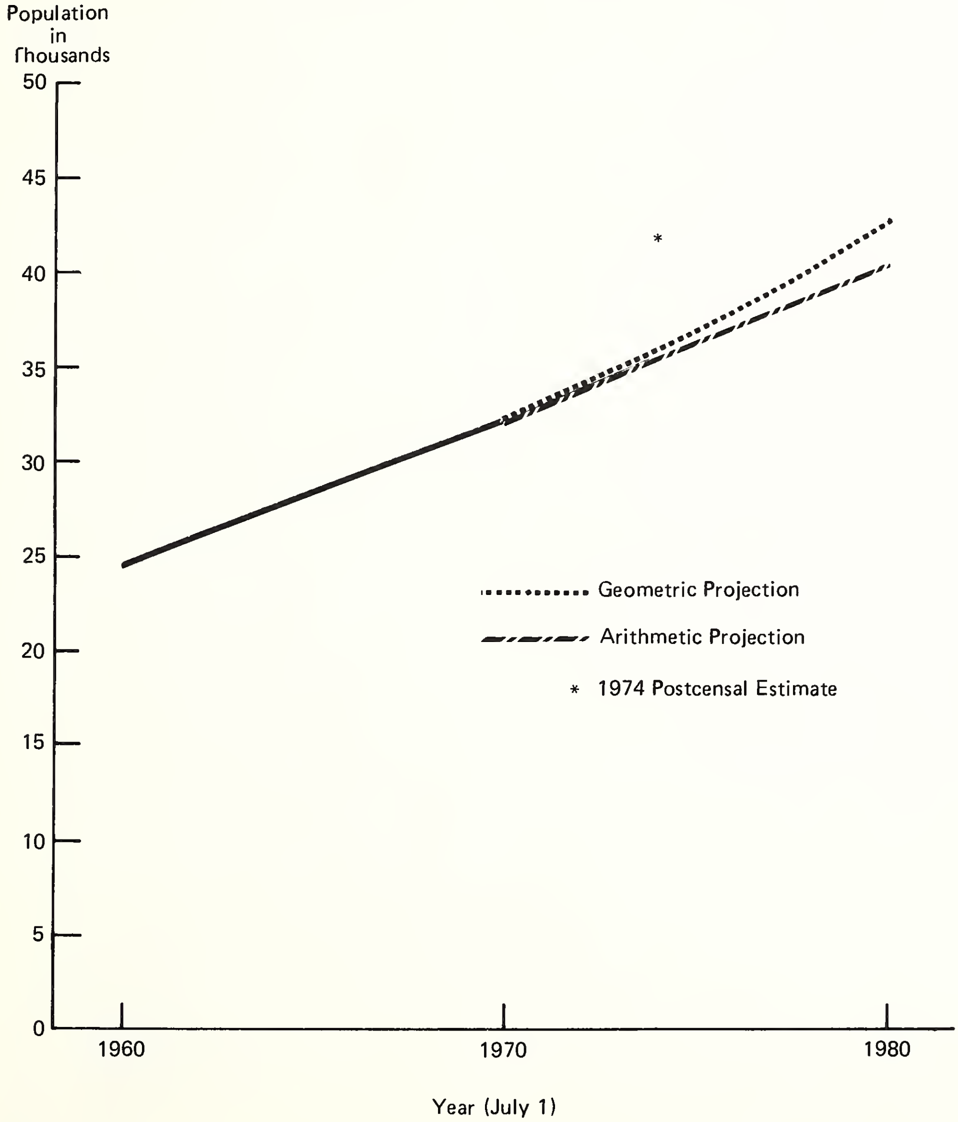
[8] Michael R. Greenberg, Donald A. Krueckeberg, and Richard Mautner. "Long Range Population Projections for Minor Civil Divisions: Computer Programs and User's Manual." New Brunswick, New Jersey: Center for Urban Policy Research, Rutgers University, 1973.

[9] Newling, op. cit.

future behavior of variables known to be related to population change is mathematically integrated into a single expression. The associations established during the base period are assumed to continue into the future. This very useful technique is often used for projecting some subset of a model, such as migration, but the dependent variable may also be population. It is not classified here as a "method," but a number of examples of its use are discussed in Section 3.24, Economic-based methods.

Figure 1. Estimated and Projected Population, "Exurban County, USA": July 1, 1960 to July 1, 1980

["Exurban County, USA" is a fictitious name for an actual county in the United States. See Appendix H Section 5.1, for a description of its characteristics]



3.22 **Ratio method.** In this method the data are expressed as shares or ratios of a larger, or "parent," population for which a projection already exists. The historical trend of the ratios is then determined, projected into the future, and multiplied by the projection for the parent population. The trend may be established by fitting a least-squares line to the historical data or by some other mathematical technique, or the projection may simply be drawn freehand on a graph.

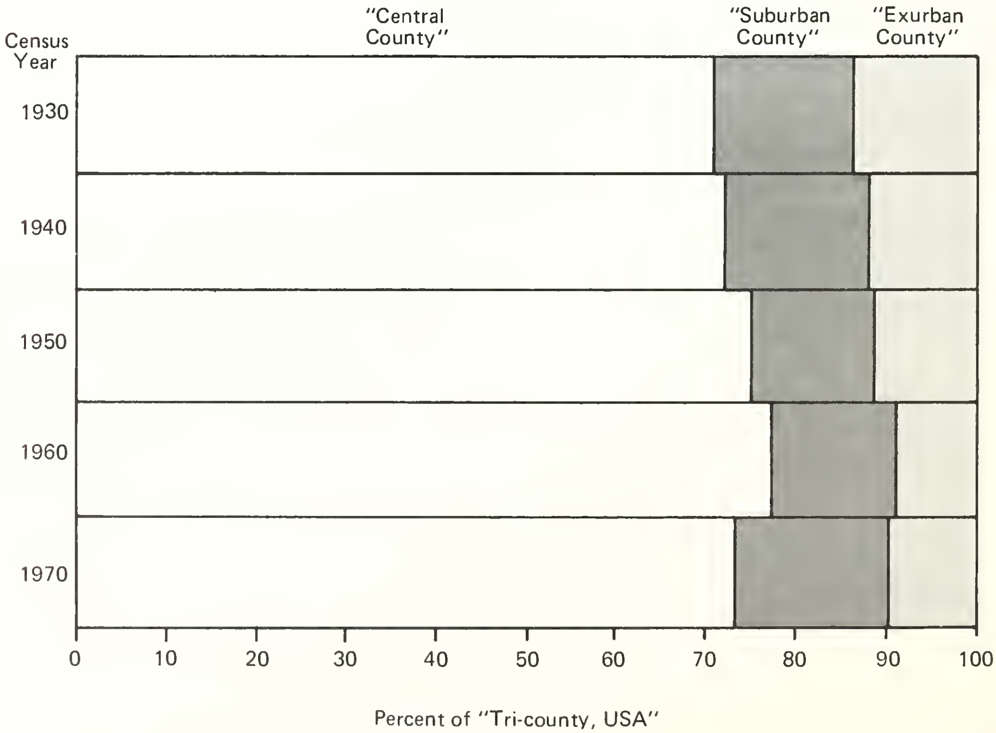
To cite a specific example, the share each county had of the total population of "Tri-county Area, USA", as shown by the decennial censuses from 1930 to 1970, is illustrated in figure 2.[10] The share for "Central County, USA" increased from 1930 to 1960. The remaining counties of the area both had decreasing shares. The situation reversed from 1960 to 1970. If these county shares (ratios) are projected to 1980 they can be multiplied by an independent projection of the total population of the area to obtain projections for each county. Observation of figure 2 suggests that the county ratios projected for 1980 will vary according to the length of the base period upon which the projection is based. If the trend from 1930 to 1960 is included in some way in the projection, the 1980 projected share for "Central County, USA" will be higher than if only the trend from 1960 to 1970 serves as the base period for projecting ratio change.

The projection of the ratios into the future is critical, and care must be taken to prevent small declining ratios from decreasing too rapidly and increasing ratios from becoming too large. One way

[10]"Tri-county Area, USA" is a fictitious name for an actual metropolitan area in the United States used in Appendix H to illustrate projection techniques. "Central County, USA" is one of the three counties making up the area. For a description of these counties, see Appendix H, Section 5.1.

Figure 2. County Share of Area Population, "Tri-county Area, USA": 1930 to 1970 (April 1)

["Tri-county Area, USA" is a fictitious name for an actual SMSA in the United States. See Appendix H, Section 5.1, for a description of the characteristics of the area's counties]



of handling this is to assume that the ratios will reach stability at a determined future date, and systematically diminish the projected amount of change.[11] Another way is to select some value for the terminal date of the projections and obtain projections for intermediate years by interpolation. Note that if a complete set of subareas is projected, the ratios must be adjusted so as to sum to 1. However, the ratio technique need not necessarily take into account all the subareas of the parent area.

A large scale application of this method has been carried out by calculating ratios of regions to the Nation, then of urban zones to regions, and finally of the metropolitan areas to urban zones, using decennial census data from 1920 to 1960.[12] Projected change in the ratios was obtained by first computing the change in each ratio for the decennial periods between censuses. These changes were assigned shifting weights according to an established plan in calculating the projected changes in ratios after 1960. A special adjustment prevented small decreasing ratios from becoming negative, while a similar adjustment automatically limits population gain for rapidly increasing ratios. A similar method is now being applied to the areas served by the Appalachian Regional Commission.

This type of across the board use of the ratio method is not the rule, however. More typically, ratios are used at some point in a projection utilizing in part a different method.

Projections were prepared for the State of Nebraska using the cohort-component method, but this projected population was then allocated to counties by a ratio technique.[13] The population of places (incorporated and unincorporated) was calculated as ratios of the counties. In projecting the ratios, consideration was given to such factors as the pace of rural out-migration, past growth rates, availability of residential land, and available transportation facilities. A county planning commission in Iowa also used ratios to arrive at a county population projection.[14]

The ratio concept has a broader aspect than simply projecting the total population of local areas. Ratios may be introduced in one part of a model, as by the Bureau of the Census in projections of births for States and metropolitan areas.[15] Although these projections use the cohort-component technique, age-specific birth rates are not projected for each State. Rather, the ratio of the general fertility rate for the State to the Nation is calculated with the most recent historical data. The projected national general fertility rate is then multiplied by this ratio to approximate the projected rate for the State. The ratio is made to gradually approach 1, thus assuming convergence toward the national average.

The ratio method can also be used to project age distributions. In this case the all-ages population becomes the parent population, and the age groups are computed as shares of the total.

The ratio method is flexible and can be applied in a large variety of situations. When used to project total population, it has the advantage of relating the projections of individual areas to a projection for a larger area, which is presumably more reliable than individual projections for the smaller areas would be. However, like mathematical extrapolation, it can produce unreasonable results, especially if projected far into the future.

3.23 Cohort-component method.[16] The cohort-component method is usually considered to be complex and sophisticated, but actually may be

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[11] This technique was used by Margaret J. Hagood and Jacob S. Siegel, in "Projections of the Regional Distribution of the Population of the United States to 1975." **Agricultural Economic Research,** Vol. 3, No. 2, pp.41-52, April 1951.

[12] Jerome P. Pickard, "Appendixes to Dimensions of Metropolitanism," **Research Monograph 14A.** Washington, D.C.: Urban Land Institute, 1967.

[13] University of Nebraska. "Nebraska Population Projections: State, County, Region and Town: 1975-2020," **Nebraska Economic and Business Report No. 6.** Omaha: Bureau of Business Research and Center for Applied Urban Research, 1973.

[14] David H. Hammond. "Linn County Population and Employment: An Analysis of Trends with Projections to 1995." Cedar Rapids, Iowa: Linn County Regional Planning Commission, 1973.

[15] U.S. Bureau of the Census. **Current Population Reports,** Series P-25, Nos. 375 and 415. See Section 5, Selected References, for a complete citation.

[16] This method is used in the step-by-step illustration in Appendix H; for this reason the discussion which follows is relatively comprehensive, especially as it relates to births and deaths, cohort change, and net migration. These subsections provide a general theoretical background for the method illustrated.

quite simply applied. The method is sometimes called cohort-survival, but the two basic concepts underlying the method are better illustrated by the words cohort-component. It should be understood that the method is not restricted to purely "demographic" applications. Cohort-component is a broad concept, and many economic-based projections (see Section 3.24) use the procedure.

The word "cohort" indicates that the computation is done by age, retaining the identity of each age group as it is carried forward through time. For example, the cohort aged 5-9 years in 1970 is projected to 1975 by appropriate adjustments for deaths and migration, at which time the cohort is 10-14 years of age. The computation is usually done by sex, and sometimes by race as well. Five-year age groups are the most commonly used with a time unit of either 5 or 10 years. Note that this unit must be in multiples of the size of the age group, in order to retain the identity of the cohort.

The notion of a cohort may be added to mathematical extrapolation and ratio techniques as a fundamental resource in making projections. It cuts across the usual method of tracing an historical series, by taking as its point of reference the successive experiences of a group of people as they age through time. In addition to the projection of population by age, as described here, the cohort technique has been used to project school enrollment, fertility, household formation, labor force activity, and other characteristics (see Section 3.3).

To consider next the "component" concept, population change is taken to result from the interaction of three components, as shown in the expression:

$$P_1 = P_0 + B - D + NM \qquad (3.1)$$

Where P_0 is the population of an area at the beginning of some period, P_1 is the population at the end of the period, B and D are births and deaths, and NM is net migration, that is, the difference between the number of persons who move into the area (in-migrants) and the number who move out (out-migrants). As will be discussed further on, separate computations for in- and out-migrants are sometimes made, and international migration may be treated separately.

The cohort-component method has been criticized as being mechanical and unrealistic, but in fact these criticisms are applicable to the manner in which it is applied, not to the method itself. The projection of the various components into the future need not be a simple extension of past trends. There are different techniques for projecting each component, and once specific techniques are selected, assumptions are made about the expected future behavior of each component. If these assumptions turn out to be correct, and there is no error in the basic historical data (population, births, deaths, and migration), or in the calculations, the future population will be exactly as predicted. In this sense the method is strictly logical.

The problem, of course, is to make correct assumptions, and the task of the user is to evaluate them. Forecasting the future behavior of the components has not proved easy, and there are problems with the basic data used as input. Before discussing the limitations to the use of the cohort-component method suggested by these problems, and its advantages (Section 3.235), it will be useful to discuss the technical aspect in more detail.

3.231 **Projections of fertility.** Special procedures are always required in cohort-component projections to take account of the population born after the beginning date of the projections. The number of births need not necessarily be projected; in making a projection to 1980 from a base date of 1970, the population under 10 years of age in 1980 can be estimated by means of a child-woman ratio.[17]

However, in the United States, detailed birth data are available for counties and sometimes for other small areas as well, and the usual procedure is to project age-specific birth rates or the general fertility rate. The use of the more sophisticated cohort fertility method is sometimes carried out at the State level.[18] Cohort fertility projections require so much detail that they rarely appear in local projections. The national population projections developed by the U.S. Bureau of the Census use this method, and a description of the technique and

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[17] Henry S. Shryock, Jacob S. Siegel, and Associates. "The Methods and Materials of Demography." Washington, D.C.: U.S. Bureau of the Census, U.S. Government Printing Office, p. 797, 1971.

[18] California Department of Finance. "Population Projections for California Counties, 1975-2020." Sacramento, California, p.3, 1974.

other related information will be found in the most recent published projections.[19]

A common approach in projecting births for States or counties is to work with age-specific fertility rates by age of mother in 5-year groups. These are calculated for dates in the past and projected into the future either on the basis of past trends or some more refined procedure, or by reference to an already prepared projection for a larger area—the State or the Nation—using a ratio technique. The latter procedure is recommended as being simpler, since in projections for local areas, there is more advantage in focusing on the analysis of migration.

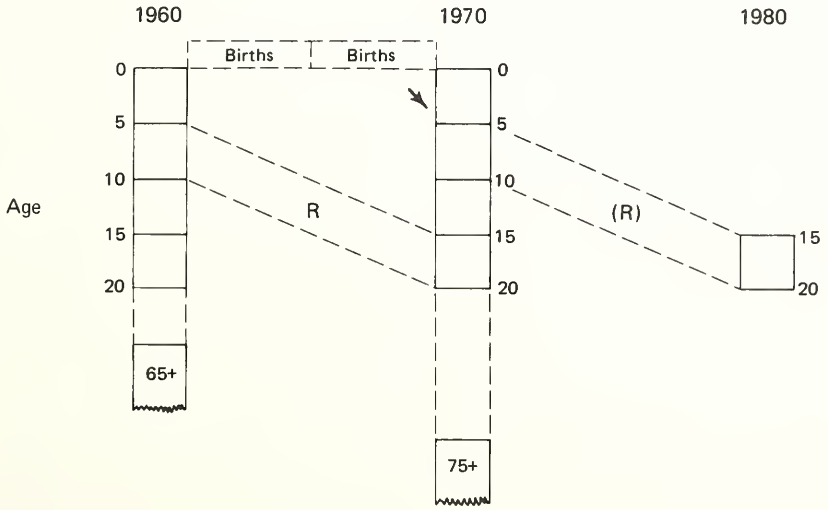
Although it is common to use age-specific rates for counties, it may be more accurate to use the general fertility rate, because an error in projecting the age detail for the migration of young adults can have a very large impact on the birth projections. Unless there is confidence in the 5-year age detail, the general fertility rate is to be preferred. The projection model illustrated in Appendix H uses the latter.

With respect to accuracy, the projection of births for small areas is subject to all the hazards of projections at the national level, plus the local variation which might result from inaccurate basic data, or change in the socioeconomic character of the local area during the projection period, relative to the nation. For these reasons, alternative projections of births are often included in population projections for local areas. An example of such alternative projections is given in Appendix H in the step-by-step illustration of the cohort-component method. See Effect of alternative fertility assumptions in Appendix H, Section 3.22.

3.232 **Cohort change.** Once the procedure for projecting births is decided, there are a number of options in the treatment of the other two components. The simplest is the "cohort change" method. The basic notion is the extension 10 years into the future of the rate of change observed for the population of each cohort between the two most recent decennial censuses, in accord with the following expression:

$$\frac{P_x^{80}}{P_{x-10}^{70}} = \frac{P_x^{70}}{P_{x-10}^{60}} \qquad (3.2)$$

where P is population; 60, 70, and 80 represent decennial census dates; x denotes an age group; and x-10 is the same age group 10 years younger. This idea is shown graphically below for the cohort 5 to 9 in 1960 becoming 15 to 19 in 1970:



(3.3)

[19] U.S. Bureau of the Census, **Current Population Reports**, Series P-25, No. 601. "Projections of the Population of the United States, 1975 to 2050." Washington, D.C.: U.S. Government Printing Office, 1975.

where the ratio R, representing the right side of equation (3.2), is assumed to continue for the succeeding decade. The formula can be applied to any local area with constant geographic boundaries during the time frame specified. The first widely known application of this formula for small area forecasting was made by Hamilton and Perry.[20]

Special procedures are required for the cohorts born during the projection period in order to obtain the population under 10 years of age in 1980. For the cohorts already born on the base date, the change in cohort size is caused by deaths and net migration; the projection assumption is that the rate of change resulting from these two components will be repeated in the future. Census errors in either census will also affect the relationship, and the projection assumes that the impact of these errors will be the same.

The method has the advantage of simplicity, but in spite of being widely recognized, has not been used often in projections which reach published form. The combination of mortality and migration in one expression makes it difficult to introduce assumptions of future change in either of the components. Nonetheless, the relationships involved in the cohort change concept underlie many of the more detailed procedures.

3.233 Projections of mortality. The most common approach in projecting the mortality component is to compute age-specific survival rates from an appropriate life table and project these "life table survival rates" (LTSR) into the future. Locally oriented technicians, such as planners for metropolitan areas, often use a State life table. If a table is available for the exact area being considered, it of course can be used. An illustration of the computation of survival rates from a life table is presented in Appendix C. National LTSR'S for the decades 1960-70, 1970-80, and 1980-90 are given in Appendix A.

If State or local LTSR's are used, they may be projected on the basis of past trends or by reference to national projections. The U.S. Bureau of the Census customarily includes a table of projected survival rates by age and sex in its reports presenting population projections for the Nation.[21]

Rather than use survival rates specific to the local area, the technician may choose to use national rates, since death rates specific by age, race, and sex are somewhat similar throughout the United States. In fact, there are differences between regions and by socioeconomic status, but any error in projecting deaths may be completely overshadowed by possible errors in the migration component.[22]

National census survival rates. The other important resource in allowing for mortality is the use of national census survival rates (NCSR). Operationally, these rates can be used in place of LTSR's and tables are presented in Appendix B for optional use in the illustrative projections shown step by step in Appendix H.

As the name implies, NCSR's are calculated for the Nation as a whole from two successive censuses. The later census is adjusted by removing the effects of net immigration from abroad during the intercensal period. The ratio of these results to the population enumerated in the first census is calculated for each cohort to obtain the "national census survival rate." The U.S. Bureau of the Census publishes a set of rates following each decennial census period.[23]

The NCSR's as calculated above implicitly include a partial correction factor for net census undercount, since errors in the National census counts due to underenumeration and misstatement of age are reflected in the survival rates. When these rates are used to calculate survivors of the population of a subarea of the Nation, the assumption is that the

[20] Horace C. Hamilton and Josef Perry. "A Short Method for Projecting Population by Age from One Decennial Census to Another." **Social Forces**, Vol. 41, No.22, pp.163-70, December 1962.

[21] U.S. Bureau of the Census. **Current Population Reports**, Series P-25, No. 601, op. cit., p. 130.

[22] In addition, an error in the mortality component tends to be counterbalanced by a shift in the estimate of net migration, in projections using estimated net migration calculated by the forward survival rate method. This is discussed in Irwin, op. cit.

[23] U.S. Bureau of the Census. **Current Population Reports**, Series P-23, No. 41, "Preliminary National Census Survival Rates, by Race and Sex, for 1960 to 1970." Washington, D.C.: U.S. Government Printing Office, 1972. For a more complete discussion of the derivation of these rates, see Shryock, Siegel, and Associates. op. cit., p.632.

impact of mortality and net census undercount on the subarea is the same as for the Nation. On the average, this assumption is justified, but for any individual area the actual rate of undercount may be very different from the national average. With respect to mortality it is possible to bring the NCSR's closer to a State-specific concept by adjusting them with the ratios of State to national LTSR's, by age, race, and sex.

Census survival rates have not been widely used in population projection models,[24] but there has been much study of their use in estimating net migration.[25] Estimates of net migration by age, race, and sex for all U.S. counties for the decade 1960-70, using a modification of the census survival rate method, have recently been published.[26] Estimates for the period 1950-60 were prepared by a similar method.[27]

Demographers have had their greatest success in projecting the mortality component. Until 1960, even a large error in the migration component did not cause a proportionate error in the projection of deaths, because migrants are predominantly in the young ages for which mortality rates are low. Since 1960 this has changed dramatically in many retirement areas, where an increase in the in-migration of elderly persons in a lightly populated area results in a substantial error in the projection of deaths. Such areas could be called special cases but nonetheless are a new problem to be faced in small area population projections.

3.234 **Migration.** The component posing the greatest problem in local population projections is migration. The Current Population Survey consistently has shown that about 6 to 7 percent of the population lived in a different county 1 year before. (The migration question related to a 1-year reference period until 1972.) The most recent survey reflects a 5-year period, from 1970 to 1975, and indicated that 17 percent of the population lived in a different county in 1975.[28] These migration rates are for the total population; for young adults the rates are much higher.

Furthermore, the United States has traditionally experienced great net migration flows. One thinks of the Westward migration, the rural to urban movement, and the migration from South to North of the Black population. In response to the problems and questions raised by these flows, and of population mobility in general, demographers have developed a wide variety of migration statistics. Two types stand out for projection purposes: (1) residual net migration calculated for intercensal periods, and (2) gross migration statistics obtained from a question in a census or survey on prior residence, as used in the decennial censuses since 1940.

Residual net migration. The amount of net migration for an area during an intercensal period can be estimated by rearranging equation (3.1) as follows:

$$NM = P_1 - P_0 - B + D \qquad (3.4)$$

where NM is net migration, and the remaining symbols are the same as in equation (3.1). This estimate of net migration is called "residual" because it represents that part of the change between P_1 and P_0 not explained by births and deaths. As such, it is an indirect measure, and the estimate of migration is affected by all errors in the counts of population, births, and deaths.

In cohort-component computations the mortality component in (3.4) is estimated by the use of

[24] For a detailed discussion of their use in population projections, see Irwin, op. cit. Tables of projected NCSR's are given in Appendix B of this guide.

[25] A good review is given by Horace Hamilton, "Effect of Census Errors on the Measurement of Net Migration." **Demography**, Vol. 3, No. 2, pp.393-415, 1966.

[26] Gladys Bowles, Calvin L. Beale, and Everett S. Lee. "Net Migration of the Population, 1960-70, by Age, Sex, and Color, United States, Regions, Divisions, States, and Counties." **Population-Migration Report 1960-70, parts 1-6.** Athens, Georgia: Economic Research Service, U.S. Department of Agriculture; The Institute for Behavioral Research, University of Georgia; and Research Applied to National Needs, National Science Foundation, cooperating, 1975.

[27] Gladys Bowles and James D. Tarver. "Net Migration of the Population, 1950-60, by Age, Sex, and Color." **Popultion-Migration Report, Vol. I.** Economic Research Service, U.S. Department of Agriculture, Washington, D.C.: U.S. Government Printing Office, 1965.

[28] U.S. Bureau of the Census. **Current Population Reports**, Series P-20, No. 285. "Mobility of the Population of the United States: March 1970 to March 1975." Washington, D.C.: U.S. Government Printing Office, 1975.

survival rates of the types discussed above. For the period 1960 to 1970, net migration would be calculated by cohort as follows:

$$NM_x = P_x^{70} - (P_{x-10}^{60})SR \qquad (3.5)$$

where SR is the survival rate (either a national census survival rate or one calculated from a life table), NM is net migration, and the other symbols are the same as in equation (3.2). The value after the minus sign is often called the "expected" population. For the cohorts under 10 years of age in 1970, the number of births for the appropriate intercensal period are substituted for P_{x-10}^{60}.

This is the "forward survival" technique and is the one most easily adapted to population projections. For this purpose, net migration is usually expressed as a rate by dividing by the expected population—the initial population can also be used—as follows:

$$RNM = \frac{P_x^{70} - (P_{x-10}^{60})SR}{(P_{x-10}^{60})SR} \qquad (3.6)$$

where RNM is the rate of net migration.

The most common projection procedure is to assume that rates calculated in this way for the historical base period will continue in the future. This procedure is closely related to the "cohort change" technique, because if the survival rate as well as the net migration rate is held constant, it can be shown that the projected population is exactly the same as would be obtained by the use of formula (3.2) rearranged as follows:

$$P_x^{80} = \left(\frac{P_x^{70}}{P_{x-10}^{60}}\right) P_{x-10}^{70} \qquad (3.7)$$

Formula (3.7) is the "projection of past trends" which is cited by critics of the method as being mechanical and unrealistic. To a degree they are correct, although the assumption is not altogether unrealistic because net migration trends tend to be persistent. However, the longer into the future these trends are projected, the weaker becomes the rationality of the procedure.

If projections are prepared for a set of subareas, for example all counties of a State, the assumption of a continued rate of net migration creates a difficulty of a mathematical nature. The rapidly growing areas with a net in-migration grow more and more rapidly as the projection period is extended, demanding more and more net migrants. The areas with lower rates of net in-migration or with net out-migration are not growing as rapidly or are losing population. The total net migration computed as the sum of the individual area calculations tends to exceed the value calculated by the same technique for the area as a whole. The greater is the variation in growth rates among the subareas, the greater the imbalance, and as the projection period is extended, the imbalance becomes progressively more severe.

Various means have been developed to adjust the parts to sum to the control total for the whole, but the problem is difficult, especially when some of the areas have net out-migration. One of the techniques used in this situation is the plus-minus adjustment. An illustration of its use is given in the illustrative population projection in Appendix H.[29]

There are, however, alternatives to the assumption of a continuation of rates into the future. The in-migration areas can be restricted in the growth rate allowed, thus diminishing the size of the adjustment to the subarea totals. A simple restriction would be that the projected number of net migrants is not allowed to exceed the number estimated for the base period, or could exceed it only by a certain proportion, based for example on the anticipated growth in the size of the gross migrant pool for the Nation. (See below for a discussion of this concept.) This restriction could be specific by age, if desired. Such measures would diminish the degree of imbalance and the adjustment required.

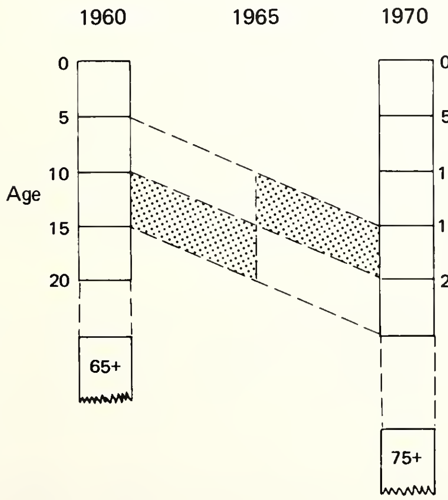
In fact, any control total for net migration obtained by independent analysis can be imposed on the cohort-component projections, for example, the

[29]The plus-minus technique is shown in table H-11, footnote 3.

output of a regression analysis, and migration totals and age distributions can be adjusted to the new controls.[30] If the particular age distribution has both positive and negative values, as is not unusual for counties, the adjustment can become a serious problem. The plus-minus technique can be used, but a new technique has been suggested to make such adjustments, whereby standard age patterns are established which can be applied according to the type of area involved.[31] If these adjustments can be made more logical as a result of this technique, or by some other means, it would be a tremendous service to this approach to population projections, because net migration is easy to calculate and can be prepared for any size area, for any intercensal period.

The "adjacent cohort" technique. An additional consideration in all cohort-component projections is the time unit used. All of the illustrations regarding net migration given thus far assumed 10-year projection periods, matching the length of the historical base period. The illustrative projections in Appendix H also use this time period. If the projections are to be carried out for 5-year periods, a problem arises in adapting the 10-year intercensal migration data to the 5-year time interval. To consider one cohort as an example, a net migration rate is needed for the cohort aged 10-14 at the beginning of a 5-year period, becoming 15-19 at the end.

During the intercensal period from 1960 to 1970, two cohorts pass through this range, as shown by the following diagram:



(3.8)

The cohort aged 5-9 becoming 15-19 has the experience in the second half of the decade, while the next older cohort has it in the first, as indicated by the shaded areas. A common practice has been to divide the 10-year rate for each cohort by two and average these rates for adjacent cohorts, obtaining an estimate for a 5-year period. There are other procedures that are somewhat more sophisticated, but all have the same basic premise.

This practice has been referred to as the "adjacent cohort" technique.[32] It works fairly well if the net migration rates do not vary too much from one age group to the other. If, however, there are large differences in rates between adjacent cohorts, the procedure results in a deviation from the original cohort migration values, producing serious errors in the projected population after 5 years, and after 10 years as well. Large variations in net migration rates from age to age are common for counties which represent only a part of a metropolitan area. A growing suburban county in the 1960's typically experienced net in-migration of Whites at about ages 25 to 40 and under 15 years. These, of course, are the large families who migrated to the suburbs during the period. But in the same county there is often an out-migration or a much lower in-migration at ages 15 to 24, as the older children reach the age to attend college, take a job, and marry. These persons gravitate to the central city where they are closer to their employment and find smaller housing units at a rental they can afford. The central city thus tends to have opposite flows from those of the suburban county, and typically at a high rate.

In these situations the adjacent cohort practice can lead to errors in the order of 10 percent or over where moderately heavy migration flows are involved. This has been demonstrated with gross migration data from the 1970 census.[33] Migration statistics for a 5-year time period for a suburban

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[30] In the step-by-step illustration given in Appendix H, the precise use of such an independently derived projection of net migration in table H-4 is described at Step 7 of Section 3.3.

[31] Donald B. Pittenger, "A Typology of Age-Specific Net Migration Rate Distributions." **Journal of the American Institute of Planners**, Vol. 40, No. 3, pp. 278-83, 1974.

[32] Richard Irwin, "Use of the Cohort-Component Method in Population Projections for Small Areas." Paper prepared for the Conference on Population Forecasting for Small Areas. Oak Ridge, Tennessee: Oak Ridge Associated Universities, 1975.

[33] Ibid., pp.14-17.

county were manipulated so as to show the effect of the adjacent cohort averaging technique. After combining the 5-year data to form rates for 10-year periods, the 5-year data were "recreated" using the averaging technique. The results of these computations are as follows:

Age		Original rates	"Recreated" rates	Difference ("recreated" minus original)
Beginning of period	End of period			
5-9	10-14	8.5	9.4	0.9
10-14	15-19	4.4	6.2	1.8
15-19	20-24	7.4	13.4	6.0
20-24	25-29	36.0	25.6	-10.4
25-29	30-34	24.8	24.8	0.0
30-34	35-39	13.8	15.8	2.0

The deviations of the "recreated" net migration rates from the original values are substantial for the two age groups with initial ages 15-19 and 20-24 years.

Faced with this degree of distortion, the use of the adjacent cohort technique is not recommended if the distribution of net migration rates by age shows substantial deviations between adjacent cohorts. A better procedure is to project for a 10-year period, and obtain population data for intermediate years by interpolation, age by age. This is the procedure followed in the step-by-step illustration of the cohort-component method in Appendix H.

Gross migration. However, there are more fundamental problems in the use of net migration in population projections.[34] Migration is in reality a two-way phenomenon, consisting of out-migrants and in-migrants. "Net migration" is in a way a statistical artifact; there is no person who can be termed a net migrant. This theoretical objection contributes to the mathematical difficulty in adjusting net migration projections discussed above after formula (3.7). For these and other reasons, interest has been growing in the analysis and use of gross migration data, whereby for a given area, out-migration and in-migration are shown separately.

One way of obtaining gross migration statistics is through questions in censuses and surveys, asking the residence of the respondent at some prior date. Such questions have been included in the decennial censuses since 1940 and are asked annually in the Current Population Survey. From these data a wide variety of migration statistics can be obtained, such as place-to-place migration streams, gross in-and out-migration for each place, and net migration. All of these can be used as basic data for population projection models.

In its population projections for States and metropolitan areas, the U.S. Bureau of the Census has used the gross migration data provided by the 5-year retrospective question on migration in the decennial census.[35] These "demographic" projections use conventional techniques for birth and death projections but make separate computations for in- and out-migration. For each area, out-migration by age, race, and sex is projected first using <u>rates</u> observed during the base period. The out-migrants from all areas are summed to form a national migration pool. This pool of migrants is allocated back to the subareas on the basis of the <u>proportions</u> observed in the base period census data. This procedure has the effect of causing the net migration projected for the various areas to converge toward a central value as the projection period is extended.

Gross migration data are closer to the real process of migration than are net figures, and their use in projections avoids some of the problems which appear in net migration models. For example, the sum of all out-migrants automatically equals the

[34] Additional material can be found by consulting works included in Section 5, Selected References.

[35] U.S. Bureau of the Census, **Current Population Reports,** Series P-25, Nos. 375 and 415. See Section 5, Selected References, for complete citations.

sum of all in-migrants in the gross migration procedure outlined in the preceding paragraph. In projections using rates of net migration, as mentioned earlier, the sum of net in-migrants always tends to exceed the sum of net out-migrants, and a special adjustment must be carried out.

The migration process is even more closely represented by place-to-place statistics. Data of this type have figured in analytical studies from time to time, but have not been incorporated in the preparation of published population projections for local areas.

Net immigration from abroad. Since net civilian immigration has been about 25 percent of total U.S. population growth in recent years, it should be either explicitly or implicitly taken into account in preparing population projections for local areas affected by international migration. Intercensal estimates of net migration for local areas by the residual method implicitly include net movement of all persons from abroad (including members of the Armed Forces if no special adjustment is made for the military population). If it is assumed in a projection model that past net migration trends will continue, the implicit assumption is that the international portion will also continue. Users and producers of population projections should be aware of this aspect of a net migration assumption, even if no special adjustment is required.

By contrast, gross migration statistics obtained from census questions about prior residence cannot include net international movement, because the question is only put to persons residing inside the country and to American citizens abroad. These statistics show all internal in- and out-migration, but typically reflect only the total movement into the country from abroad. If gross migration statistics are used in a projection model, net immigration from abroad must be explicitly introduced if it is to be taken into account. The 1970 census provides information which can be of assistance in quantifying this component (tables 119, 144, and 145 of the State volumes, et al).

3.235 Advantages and limitations of the cohort-component method. Whether or not to use the cohort-component method in preparing a set of population projections is one of the most basic decisions to be made. It is therefore important to be familiar with the advantages and limitations of the method. These can be considered under two categories: (1) level of detail, and (2) geographic unit of reference.

Level of detail. A cohort-component projection involves a good deal of detail, even for a simple model. Other things being equal, a more sophisticated method should give better results. There are, however, both positive and negative aspects to the relatively large amount of detail. On the positive side, the detail by age—and by sex and race if desired—is useful for many planning functions. Medical facilities and services are often aimed at a certain age range, for example, pediatrics, cardiology, and geriatrics; or may be specific by sex, e.g., prenatal care. Housing needs are also specific to the age of the user. Interest has been growing in the aged population, since providing services for retired persons has become an important part of the national economy. Planning for all these functions requires accurate projections by age and justifies the time to produce them.

Another advantage of the component approach is that the data produced on births, deaths, and migration are useful for planning in themselves. In addition, the analyst has the option of using greater detail on the component most fundamentally related to the problem at hand.

By contrast, the high level of detail also requires more data as basic input, and more calculation. The latter can be done by computer, but if only a few areas are involved, use of the computer may not be justified. The input data on population and vital statistics have to be prepared by hand in any case. If corrections are needed for a special population, additional time is required to collect the data if available, or estimate it, if not. All in all, a set of projections by this method is a major undertaking.[36]

Geographical reference unit. The cohort-component method produces the best results when working with a labor market area as a unit, for example, an SMSA. Logically the method is perfectly applicable to any area, no matter how small, whose geographic boundaries are fixed and for which the basic data can be obtained. Practically, however, as the area becomes smaller, both in land area and population size, the difficulty of using the method increases. Migration between SMSA's is a fundamental alteration of a person's social and economic ties, usually involving a change of employment. Migration rates are low, relative to smaller

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[36] See Section 2.32, Complexity of method, for a general discussion of the advantages and disadvantages of the more complex methods.

areas, and the age distribution of migrants is closer to the national mobility pattern, making the projected age detail more reliable. Within an SMSA there is much migratory movement to obtain suitable housing and various services, as family composition changes through time. This results in very high net migration rates for small areas and sharp variation from one age group to the next.[37] The smaller the area, the higher the migration rate across its boundaries.

At the county level, the cohort-component method is still manageable. Most counties are fairly large in land area and encompass persons of heterogeneous social and economic characteristics, so that no single event will completely change the population picture. For a census tract or smaller area, a single large new apartment house will be translated into very high rates of net in-migration. It is difficult to adjust these rates for expected future development of the area. For such small areas, some other method based on housing change and population density is indicated.

In using the cohort-component method on local areas, the geographic size of the area has an important influence on the selection of the type of migration data to be used, gross or net. For large areas like SMSA's, either gross or net migration techniques can be used, but gross migration is preferred because of the closer relationship to the real migration process, with the possibility of separate determination of the factors affecting in- and out-migration. However, net migration is simpler and easier to calculate, and may be preferable if a single local area is under consideration.

At the county level, and for areas of small population size in general, gross migration data have not been readily available; and data from the decennial census, if tabulated, may have too large a sampling variation to recommend their use. Corrections for special populations require more detailed computations, which in turn are dependent on the form of tabulation of the census data on gross migration. Estimates and projections of net migration are independent of this restriction, and adjustments for special populations can be designed to fit the specific local situation.

Errors of measurement in basic data. Each component has its own special problems. Although birth registration was shown to be nearly complete by a recent nationwide study,[38] there are problems in the proper allocation of births to the place of residence of the mother. In general this is believed to be accurate at the county level, although there are indications that births to Black residents of some suburban counties in the South are not attributed to the proper county.

As to the mortality component, the number of deaths estimated by life table survival rates may differ from registered deaths for a given small area for several reasons. (1) There are real differences in mortality between regions and between socioeconomic classes. A life table which relates strictly to the population of each local area is not always available. (2) There are random fluctuations in the number of deaths for a small area. (3) There is the allocation of deaths in institutions to place of former residence. This is the recommended practice, but it is not always logical, since the deceased may have been institutionalized for a long period of time. There may also be errors in the allocation process. In any case, a cohort-component computation will automatically assign these deaths to the institutional location.

Finally, a technical problem in projecting deaths is the failure of the forward survival method—the most convenient to use in net migration projections—to take deaths of migrants into account. In the case of net in-migration, the tendency is to underestimate deaths, with the reverse tendency for out-migration. In general, migrants are young people, for whom death rates are low, and the error is not large; but for retirement communities, this factor must be kept in mind.

If the projection model uses residual net migration, errors in the birth and death components are compensated by the migration component, and the projected population remains essentially the same as would be obtained by the cohort change procedure of formula (3.2). A calculation using gross migration data will not have this element of compensation; errors will be reflected in the final population projection. For example, if the survival rates yield too many deaths, the projected population will be lower than intended.

The gross migration data are obtained in a census and reflect net census underenumeration, and misre-

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[37]See Section 3.234, Adjacent cohort technique, for comment on the age distribution of net migrants.

[38]U.S. Bureau of the Census, Census of Population: 1970. **Evaluation and Research Program**, PHC(E)-2, "Test of Birth Registration Completeness, 1964 to 1968." Washington, D.C.: U.S. Government Printing Office, 1973.

porting of age and other information. In addition, it is believed that migrants are less completely enumerated than the general population. Once enumerated, the accuracy of the data depends on the ability of respondents to give accurately their residence exactly 5 years earlier; if they were in the Armed Forces or in college, they were expected to give residence there, not at the home of their parents.

There is also the problem of nonresponse. The migration statistics from the 1970 census show that 11.1 percent of the persons who reported that they had moved between 1965 and 1970 did not indicate their place of residence in 1965.[39] For the Black population the figure was 17.2 percent. These persons were not included in the gross in- and out-migration statistics since the origin of their move is not known, and they were not assigned anywhere as an out-migrant. A special tabulation of the 1970 census gross migration data has been prepared at the Census Bureau, in which nonresponse on this item was allocated on the basis of other information.[40] These data will be suitable for use in population projection models.

With all these problems, special interest attaches to the use of administrative records to obtain migration statistics. The Bureau of the Census has been working with records of the Internal Revenue Service (IRS) to estimate migration. Net migration calculated from this source was used in preparing population estimates for small areas under the Federal General Revenue Sharing program, but it is also possible to obtain gross migration data for States and counties. Potentially, the method could produce place-to-place flow data. There are limitations due to coverage and reporting of residence, however, as well as the purely mechanical concerns of access to files, the expenses involved in processing large computer files, and related issues. The Continuous Work History Sample (CWHS) of the Social Security Administration is another set of administrative data that has been used to obtain migration statistics. See Section 4.4 in the section on data sources for comment on the CWHS, and for a reference to material evaluating the use of IRS and CWHS data in generating migration estimates.

Use of the cohort-component method is increasing, and problems in its use are being resolved. The method provides a flexible instrument which can be fitted to the particular needs of a project. For example, the method serves as a basic framework for many economic-based population projections. If projections by age are desired, the cohort-component technique will usually find a place somewhere in the projection model.

3.24 **Economic-based methods.** In the interest of making better forecasts of population, there has been growing interest in basing the projection of population, or of migration, on projected economic data. This interest was stimulated by a study by Lowry[41] examining the relation of migration streams to unemployment rates, wages, labor force size, and distance of move. Lowry found that unemployment and wage rates at the point of destination significantly influenced in-migration. In another model presented in the same study, he found a very high correlation between the volume of net migration and change in employment. Lowry concluded, however, that his results did not indicate a causal relationship of employment to migration, but that there was a "series of feedbacks or mutual adjustments between migration and the demand for labor."[42]

Many economists nonetheless believed that migration should be made a function of projected employment in population projections. Prior to the appearance of Lowry's study, projections had been prepared for labor market areas in Oregon whereby the size of the migration component was determined by an employment projection.[43] More recently the State of Pennsylvania has prepared a comprehensive set of projections with a similar basic premise.[44] A cohort-component projection assuming zero net migration was made for each subarea to produce a "closed population," and labor force participation rates were projected by age and sex. The closed population multiplied by the participation rates yielded the labor supply in the absence of migration. After allowing for unemployment, the difference between this supply and the employment projected

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[39] U.S. Bureau of the Census, Census of Population: 1970. **Subject Reports**, PC(2)-2B. "Mobility for States and the Nation." Washington, D.C.: U.S. Government Printing Office, p.1, 1973.

[40] For further information, see Section 4.4.

[41] Ira S. Lowry, "Migration and Metropolitan Growth: Two Analytical Models." San Francisco, California: Chandler Publishing Company, 1966.

[42] Ibid., p.44.

[43] Richard B. Halley and Morton Paglin. "Population Forecast, State of Oregon and Economic Areas: 1960-1985." Portland, Oregon: Oregon State Board of Census, Portland State College, 1964.

[44] Pennsylvania Governor's Office of State Planning and Development. "Population and Labor Force, by Age and Sex—to 1990." **Pennsylvania Projection Series, Report No. 73,** Harrisburg: Commonwealth of Pennsylvania, 1973.

by an economic model determined total migration for the labor force. The age and sex distribution of the migrants needed to provide the employemnt differential was obtained by adjusting residual net migration estimates for the 1960-70 decade.

In broad outline, this is the approach used by the National Planning Association (NPA) in preparing population projections for subnational areas. The NPA pioneered in the establishment of the method; their most recent projections for States were published in 1972.[45]

A projection model for development districts in Tennessee[46] utilized similar elements to obtain detail by age and sex, and the model provides for interaction among various subsystems. The key projection of total net migration, however, is determined by a regression equation in which the independent variables relate to college enrollment, income, employment, rate of unemployment, and labor supply.

A problem common to all regression formats is the necessity to project the independent variables before the regression equation can produce the projected dependent variables. One study used some unusual independent variables in a regression equation for determining net migration in developing cohort-component projections for counties.[47] The independent variables are: (1) number of superhighways, (2) number of colleges by type, (3) previous migration rate, (4) number of cities over 10,000 population within 30 miles, (5) number of cities over 20,000 lying 30 to 80 miles away, and (6) distance from a large out-of-State metropolitan area (30 to 80 miles). The externally prepared projections needed for these independent variables are subject to relatively small error.

The U.S. Bureau of Economic Analysis has prepared population projections for the 173 economic areas they have delineated.[48] They projected total employment for each area from a procedure initiated by a projection of labor earnings, industry by industry, in "export" industries, augmented by "residentiary" employment. The projections of population were then obtained as a function of changes in area employment. However, in order to reflect properly changes in population which are not related directly to economic opportunity, the 1970 population in each economic area was grouped into three age categories and each was projected independently. The three groups were: (1) the labor pool (ages 14-64), (2) the pre-labor pool (ages 0-13), and (3) the post-labor pool (ages 65 and over.) The population in the labor pool was projected as a function of area employment. The pre-labor pool was projected as a function of the labor pool, but the post-labor pool was projected independently. Although the population and employment projections are initially prepared for the 173 economic areas, the data are subdivided and reaggregated to provide data for States and SMSA's.

The use of the BEA economic areas is an important advance in linking economic data to population dynamics. The areas are drawn to delineate labor markets. As such, the patterns of interarea migration should be more susceptible to economic-demographic analysis, because a job shift from one area to another almost surely means a matching migration of the job holder. Within labor market areas there is heavy migration from one jurisdiction to another with no change in site of employment by any member of the family. Unfortunately, census data on gross migration for BEA economic areas have never been available, but are included in a special tabulation for the period 1965-70. (See Section 4.4)

None of the published economic-based population projections reviewed here used gross migration data. However, as an outgrowth of Lowry's work[49] a series of theoretical studies have investigated the separate characteristics of in-migration and out-migration. Working with gross migration data for State economic areas, Olsen developed a model for projecting in-migration and out-migration rates by age.[50] He used a single-equation model, with the dependent variable being either in-migration or

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[45] Joe W. Lee and William B. D. Hong. "Regional Demographic Projections: 1960-1985." **1972 Regional Economic Projections Series,** Report No. 72-R-1. Washington, D.C.: National Planning Association, 1972.

[46] Richard A. Engels and Annie A. Moore, "Tennessee Migration, Population, Families, Income, and Manpower Demand Projections to 1990, for Development Districts and Counties." Nashville, Tennessee: Tennessee State Planning Office, 1974.

[47] Kentucky Program Development Office. "Kentucky Population Projections, 1975-2020, Vol. I." Frankfort: Commonwealth of Kentucky, 1972.

[48] U.S. Bureau of Economic Analysis, Department of Commerce. "Area Economic Projections 1990." Washington, D.C.: Government Printing Office, 1974.

[49] Lowry, op. cit.

[50] Richard J. Olsen. "Population Migration: State Economic Areas in the Interior Southeast," **Regional Environmental Systems Analysis Report No. 74-13.** Oak Ridge, Tennessee: The Oak Ridge National Research Laboratory, 1974.

out-migration rates by age. The independent variables relate to unemployment, population density, presence of college and military population, occupation, race, and labor force participation. A key characteristic is that migration is analyzed not only in terms of economic data for the area but also in terms of the characteristics of persons, such as educational attainment. An important feature of Olsen's work is the use of "pooled cross-sectional" data. This technique is described as a pseudo time-series analysis whereby the change in the relationship between the variables between two points in time is the critical factor. In his analysis of gross migration rates, both the 1955-60 and the 1965-70 data are incorporated in the regression format.

A more recent study by Kleiner extends the investigation by using different variables in the equations for in- and out-migration and by including separate data by race.[51] Kleiner used data for States and tested his model on 15 States by preparing "projections" to 1970 and comparing them with a projection using demographic data only.

These and other studies are producing new insights into the interrelationships between the migration process and the economic and social characteristics of places and persons. The key assumptions as to future migration flows in population projections can be more closely related to the real process of population redistribution.

However, research up to now has usually been directed toward showing that migration is caused by the various factors used as independent variables in a regression format. This causal relationship has not been satisfactorily demonstrated, and the interaction of migration with the economy, "the series of feedbacks or mutual adjustments" in Lowry's words,[52] still remains to be discovered. Nonetheless, the linking of demographic and economic projections is desirable, in that mutually consistent projections of the two disciplines are useful as planning tools. It is not necessary to establish the causal effect of one on the other, and future research can profitably explore the relationship without assigning either as the prime mover. The user of either the economic or demographic projections from such an integrated set should keep in mind, however, that there may be a circularity in the influence of demographic and economic factors in the construction of the system, which may lead to an unjustified confidence in the reliability of the projections.

3.25 **Land use methods.** A final category of population projections centers on the spatial aspect of population growth. One approach often used by city planners is the "saturation" method. Given a certain pattern of land use, as specified by zoning ordinances, how many housing units by type can be accommodated, assuming full utilization? The addition of an assumption as to average number of persons per housing unit produces a population projection. The city planner frequently has accurate data on housing for very small areas on a current basis. Of course zoning ordinances can be changed, and an error can also be introduced by unexpected change in average household size. The method is, however, well suited to small areas like census tracts.

A different approach to projections for census tracts was taken by a group in Oregon for a four-county health planning area.[53] Briefly, a regression analysis suggested that 1970-73 changes in housing were related to changes from 1960 to 1970, and to housing density levels. The analysis was carried out by type of structure, that is, single family, multi-family, and trailers. Changes in housing by type were projected from 1970 to 1980 with these relationships. The model was iterated to extend the projections, with increasing housing density acting as a constraint. The population implied by these projections was controlled at each decennial date to a previously prepared demographic population projection for the entire area. The change in housing stock by type also determined change in the distribution of population by broad age groups.

Another method with a new approach was demonstrated on New Jersey minor civil divisions and elaborated by the Rutgers group.[54] For lack of a better category, it is discussed here under land use because popuation density is the critical factor, measured in two ways: (1) change over time, and (2) level.

A relationship between the rate of change in population density and the level of density is

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[51] Morris M. Kleiner. "An Analysis of Interregional Migration for Manpower Planning." Urbana, Illinois: Center for Advanced Computation, University of Illinois, 1974.

[52] Lowry, op.cit., p.44.

[53] Portland State University, Center for Population Research and Census. "Population Projections to the Year 2000: Oregon Administrative District 2." Portland, Oregon: Comprehensive Health Planning Association for the Metropolitan Portland Area, 1975.

[54] Newling, op. cit., and Greenberg, Krueckeberg, and Mautner, op. cit.

established by regression, and is incorporated in a mathematical expression which sets a limit to the increase in density as the projection is extended. Since the area is fixed, the limit on density is a limit on population. This model is dependent on the mathematical resolution of the dynamic factors in the equations, which in turn are determined by the pattern and pace of the changing geographic distribution of the population in the 1950's and 1960's. It is unlikely that these patterns will be maintained in the future, due to changing relationships between personal income and the cost of land, construction, and transportation. In addition, the model assumes that the relation between different geographic areas at a single point in time is valid as a guideline for future growth of a single geographic area during the passage of time.

3.26 Trends in methodological development. It is interesting to note that density was used as an independent variable by Kleiner and appears in the Portland State model. When dealing with small land parcels with high population density, or the potential to attain it, density must not be overlooked. But a simple density ceiling is of doubtful value. Changing costs of house construction and commuting, and in the price of land, have the force to crumple existing patterns of land use. Still, the developments in projecting by land use methods are among the most interesting in the field, especially for very small areas. Other significant trends are the increased use of the cohort-component technique, and the incorporation of economic factors in projections of migration.

3.3 Methodology for Projections of Miscellaneous Population Characteristics

Mention has already been made of the wide application of ratio and cohort techniques in projecting various population characteristics (Sections 3.22 and 3.23). This section will outline the principal techniques and considerations involved in the projections of such characteristics as school enrollment, labor force participation, numbers of households, health-related characteristics, income, urban-rural residence, and others. A thorough discussion of each of these subjects is beyond the scope of this guide, but some general information will help the local analyst to recognize their function, if included in a population projection project.[55]

[55] For a detailed discussion of this subject, see "Appendix A, Methodology of Projections of Urban and Rural Population and Other Socioeconomic Characteristics of the Population," in Shryock, Siegel and Associates, op. cit., pp. 841-63.

Projected characteristics can help in evaluating the population projections. Current annual data are available for some characteristics and can be used to monitor the projections. For example, school enrollment is almost invariably available annually in considerable detail and can be used to check on the projections of the youthful segment of the population. Employment is another such series, and building permits may be compared with projected change in the number of households. Of course, such projections are primarily prepared to obtain a projection of the characteristic itself, but the evaluation function should not be overlooked. A simple example to illustrate the use of labor force participation rates for this purpose is presented in Appendix G of this guide.

3.31 Cohort techniques. A general review of current methodology for the projection of population characteristics can best be approached under two headings: (1) cohort-related techniques, and (2) the participation rate method. The latter is related to the ratio method (Section 3.22).

The cohort approach is very simply illustrated by the use of grade progression ratios to project school enrollment. Enrollment by grade for successive years is assembled, and the ratio of the enrollment in grade x in one school year to that in grade x minus 1 in the preceding year is computed for all grades. A time series of such ratios is calculated, and the observed trend projected into the future. Some way of obtaining first entries into the system at the beginning grade must be included, usually involving the projection of births. Note that the progression ratio implicitly includes migration, mortality, and drop-out rates in one factor, somewhat in the style of the "cohort change" technique (Section 3.232). The projection of enrollment by cohort can be carried out in more detail by taking separate account of entries and departures, with the whole population in the model, including those not enrolled. The application of cohort analysis to fertility has been the subject of much work and study by demographers during the past 15 years. A whole new body of statistics was created by assembling historical birth data by cohort, and the Bureau of the Census uses this technique in projecting fertility in the national population projections. This method is analytically superior but involves detailed input data and complicated statistical techniques not appropriate at the local level.

There has been continued interest in projecting families by the cohort method, although rather complex models are needed. Creation of new families, and dissolution of existing ones, can be

carried out by cohort in varying degrees of detail. Marriages, divorces, and deaths all must be considered relative to their assumed impact on family formation and dissolution. All statistics must be by age and be systematically arranged by cohort. If different types of families and family size are included, the model quickly becomes complex. Projections of the labor force by cohort present somewhat similar problems.

The above discussions of cohort applications imply what might be termed an "aggregate" approach. The actual population being projected is carried forward by age, subdivided into various categories, and the categories adjusted by accessions and diminutions.

Simulation models take a very different approach. Here one hypothetical person at a time is processed through a series of probabilities (by computer necessarily) which approximate a life cycle.[56] In projections of marriages and families, for example, the first "person" processed may never marry, since there is a chance at every age of remaining single. The next "person" run through the schedule probably will marry, since the probabilities of marrying, to which each individual is subjected at each age, are high in the young adult years. After the required number of individuals are processed, based on the needed sampling confidence limits, a population takes form at each point in time, classified by all the characteristics which were included in the model. This distribution is then superimposed on the actual population to obtain the final projections.

Simulation models have not been extensively used in published population projections for local areas. The models are complicated, being patterned after real life choices, and computer costs are high. However, simulation techniques are very useful for studying the interaction between changes in various factors affecting the life cycle.

3.32 **Participation rates.** Projections of population characteristics based on participation rates are much more commonly encountered than the cohort applications described above. This method presumes an already prepared population projection by age and projects the proportion of each age group which takes part in a given activity. Many activities are highly specific as to age. School enrollment is a good example; almost all children from 6 to 15 years of age are enrolled, with a decreasing proportion beyond that age. Labor force is another, with participation beginning at age 14 or 16 (depending on statistical policy), increasing to a very high proportion for adult males, and decreasing at the advanced ages.

The labor force consists of the employed plus the unemployed, and a labor force participation rate is simply the labor force divided by the population, specific by age and sex. Some of the important sources of basic labor force data needed as input are the decennial census, the monthly labor force survey conducted by the Bureau of the Census for the Bureau of Labor Statistics (BLS),[57] and the various State employment security programs. Many States have a section in their employment security office that makes labor force projections for their State, and BLS published a four-volume report which serves as a guide for developing State and local manpower projections.[58]

Labor force participation rates are fairly stable but do change in response to fundamental changes in the life style and occupation of the population; for a local area especially, rates may change due to a shift in employment opportunity, or because of a turnover in population through migration. All of these aspects can be analyzed, and the projection of the rates into the future is a legitimate undertaking, though with its own problems.[59] The Bureau of Labor Statistics prepares and publishes projections of labor force participation rates for the Nation, and from time to time for States. These projections can be used as a reference point in projecting rates for a local area. A simple example of such use is illustrated in Appendix G.

Households and families can also be projected by "participation" rates, in this case called headship rates. The ratio of household heads to an appropriately defined population, specific by age and sex, is calculated from actual data. These rates are projected forward and multiplied by the projected population, obtaining the number of future heads, and therefore, the number of households. The relationship of persons to a household or family is a fundamental characteristic but also is subject to

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[56]The term "micro-simulation" is sometimes used to describe this technique.

[57]Data from this survey are published monthly by the Bureau of Labor Statistics in **Employment and Earnings.**

[58]U.S. Bureau of Labor Statistics, Department of Labor. **BLS Bulletin 1606,** "Tomorrow's Manpower Needs." Washington, D.C.: U.S. Government Printing Office, 1969.

[59]See Sol Swerdloff, "How Good Were Manpower Projections for the 1960's?" **Monthly Labor Review,** pp. 17-22, November 1969.

change as life style changes. For young adults at the present time, for example, the proportion of households headed by young unmarried persons of both sexes is increasing, thus raising headship rates at these ages. Increasing divorce may also tend to increase headship rates, as two households may appear where one existed before. The Current Population Survey conducted by the Bureau of the Census provides current data on households and families, and the Bureau projects households and families for the Nation from time to time by this method.[60]

[60] U.S. Bureau of the Census. **Current Population Reports**, Series P-25, No. 607. "Projections of the Number of Households and Families: 1975 to 1990." Washington, D.C.: U.S. Government Printing Office, August 1975.

In projecting such characteristics as labor force status, household membership, and school enrollment by participation rates, there are almost as many variants in methodology employed as there are sets of projections. Many other characteristics have been projected by this method, such as income and educational attainment; and others could be, for example for health care, number of visits to a doctor, and food requirements, to name a few. In fact, any characteristic which varies systematically by age (and by sex and race if applicable) can be approximated by this method, though with varying degrees of accuracy depending on the stability and predictability of the particular participation rate.

A reasonably accurate projection of the age distribution of the population is of course a prerequisite, and effort spent to improve the age detail is justified in part by improvement in the projections of characteristics.

4. SOURCES OF DATA

(The references in parentheses in the text refer to Exhibit 4-A, Selected List of Data Sources, at the conclusion of this section)

The great variety of methods used to develop local area population projections and the diversity in the geographic units for which projections are made (States, counties, cities, minor civil divisions, census tracts), bring into play a large and varied reservoir of potential data sources. A complete bibliography is beyond the scope of this review; instead an outline will be presented covering the most important categories. These relate to demographic data only; for information relating to economic variables, other sources must be consulted. Some of the economic-based studies mentioned in Section 3.24 contain references and comment on basic data.[1]

4.1 Births and Deaths

The historical vital statistics needed in developing subnational population projections are provided by the national registration system. The U.S. National Center for Health Statistics (NCHS) processes the data collected by the States, and issues definitive tabulations yearly. The most recent publications at this writing are for deaths in 1973 and births in 1972 (U.S. NCHS, 1975b and 1975c).[2] More up-to-date final tabulations are available on special request. NCHS also publishes provisional data and prepares analytical studies (U.S. NCHS, 1952).

The various State offices responsible for vital statistics also publish their own reports. Many States provide preliminary data with a very short time lag, typically providing totals by county. NCHS periodically prepares a directory of the offices which produce these reports. A list of these offices is given in Exhibit 4-B at the end of this section.

The professional literature and various governmental publications provide a large amount of detailed data and analysis on fertility and mortality, especially the former. Of general interest are the national population projections of the U.S. Bureau of the Census (1975b), emphasizing fertility trends; and of the U.S. Social Security Administration (1974), with emphasis on mortality.

4.2 Population Censuses and Surveys

The enormously varied population data provided by the U.S. Bureau of the Census from the decennial censuses, the Current Population Survey, and other sources are listed in their Catalog of Publications. The current version of the basic volume covers publications from 1790 to 1972 (U.S. Bureau of the Census, 1974). New publications are compiled and presented quarterly, with monthly supplements. These are accumulated to annual volumes, the most recent of which is for 1974. The Catalog covers all types of data produced by the Bureau, including population estimates and projections, which are discussed below in Section 4.5, Miscellaneous Data Sources.

Of the standard population data produced by the Census Bureau, the regular decennial census volumes, one for each State, are of universal interest for preparing population projections (U.S. Bureau of the Census, 1972a). In addition, a series of publications are presented for census tracts (U.S. Bureau of the Census, 1972c). Data are also provided on computer tape in standard packages, and special tabulations can be obtained. The Data User Services Division was created to assist the public in obtaining information. Not as widely known is the availability of a tabulation of the population of counties on April 1, 1970, by age, race and sex, with adjustments to the basic census data (U.S. Bureau of the Census, 1975a).

Private organizations also provide basic and special tabulations of census data. Finally, special censuses of local jurisdictions conducted at their request by the Census Bureau and by some of the States provide a resource for evaluation of projections and the creation of new benchmarks.

4.3 Net Migration

The most important source of recent historical net migration for small areas is the data for counties by age, race, and sex developed by Bowles, Beale, and Lee (1975). These estimates were prepared by a

[1] See previously cited works by Lowry, Olsen, and Kleiner, cited in Section 5. Selected References.

[2] See headnote to this section regarding the references in parentheses.

modified census survival rate method. A similar technique was used in preparing estimates for the decade 1950-60 (Bowles and Tarver, 1965). For earlier decades (1870 to 1950), net migration statistics have been developed for States (Lee, Miller, Easterlin, and Brainerd, 1957).

The U.S. Bureau of the Census prepares intercensal estimates of births, deaths and net migration for counties (not by age). For the decade 1960-70, detail by race is shown for counties with a substantial Black and other races population (U.S. Bureau of the Census, 1971).

4.4 Gross Migration

A resource of growing interest to population projections is the data obtained by means of census questions on former residence. In 1950, the question related to residence 1 year prior to the census date, and in 1940, 1960, and 1970, the reference period was 5 years. These questions provide statistics on place-to-place migration streams, and on gross out- and in-migration for the various jurisdictions shown. Net migration is, of course, also obtained, being the difference between these two flows. The State economic area is the smallest unit for which tabulations are presented in the 1970 census (U.S. Bureau of the Census, 1972b). Sampling variation is a problem with small areas; in 1970 a 15 percent sample formed the basis for the detailed tabulations shown in the subject reports for migration. Detailed statistics for regions, States, and metropolitan areas are cross-tabulated with various special characteristics of migrants (U.S. Bureau of the Census, 1973a, 1973b).

There was a high rate of nonresponse to the question on residence 5 years earlier in the 1970 census, and a special file is now being processed at the Census Bureau in which the place of former residence will be allocated for persons who moved, but did not specify former residence. Tabulations by age, race, and sex and certain special characteristics are planned, and summary data will be published for States and counties. Special tabulations can be obtained at a cost by writing to the Data User Services Division, making reference to the 1970 Census Gross Migrant file.

The migration reports generated by the Census Bureau's Current Population Survey (CPS) should be mentioned, even though no data are presented below the geographic level of the four census regions. The CPS has included a question on previous residence every year since the first survey in 1947. Until 1973, the question related to residence 1 year prior to the survey date. From 1973 to 1975, the reference year was the previous decennial census date, that is, 1970. The most recent report is for 1975 (U.S. Bureau of the Census, 1975c). These reports provide information on the socioeconomic characteristics of migrants, and are very important for monitoring national migration trends on an annual basis. Migration is only one of a number of subjects for which tabulations from the CPS are prepared (U.S. Bureau of the Census, 1947a, 1948).

A relatively new resource is the Continuous Work History Sample of the Social Security file. It has recently been increased from a 1 percent to a 10 percent sample, which will greatly increase the amount of usable detail. There are serious problems, however, in the use of these data for obtaining migration statistics. The file does not regularly contain place of residence of the wage earner, only place of work; and basic coverage is a problem. There has been considerable experimentation in the use of the file to develop migration data, and the Bureau of the Census has evaluated the CWHS, as well as records of the Internal Revenue Service, as sources of migration data.[3]

4.5 **Miscellaneous Data Sources**

The population estimates and projections published by the Census Bureau provide material of direct application to local area projections (U.S. Bureau of the Census, 1947b, 1969). Current estimates are typically published annually, while projections for the Nation, for States, and for metropolitan areas are prepared on an occasional basis. The national projections especially have been widely used as reference points for projections of local fertility and mortality rates. To a lesser extent, the Bureau's projections for States have served as a starting point for locally prepared small area projections.

As to estimates, the practice of using a postcensal estimate as the starting point for projections is increasing. The Bureau annually publishes estimates

[3] Meyer Zitter and David Word, "Use of Administrative Records for Small Area Population Estimates." Paper presented at the 1974 Annual Meeting of the Population Association of America, New Orleans, Louisiana. See also U.S. Bureau of the Census, **Current Population Reports,** Series P-23, No. 31, "Use of Social Security's Continuous Work History Sample for Population Estimation." Washington, D.C.: U.S. Government Printing Office, 1970.

for States, SMSA's and counties. Some age detail is provided for States. County estimates of the total population are produced by the Federal-State Cooperative Program for Local Population Estimates. The estimates are prepared using methodology developed and tested jointly by the Census Bureau and the States, and are published annually (U.S. Bureau of the Census, 1969). A list of the addresses of the State and territory offices preparing population estimates can be found in Exhibit 5-C at the conclusion of this section. These offices may be able to provide references to local projections prepared for their States; some prepare projections themselves.

In 1974 a new series of estimates of population and per capita income for local areas were prepared by the Census Bureau for use in the Federal Revenue Sharing program. Estimates for 1973 were developed for about 38,000 local jurisdictions from the administrative records of the Internal Revenue Service and the Social Security Administration, and census data. Estimates for 1975 will be published early in 1977. See Section 3.235 under Errors of measurement in basic data for further comment.

The projections published by the U.S. Bureau of Economic Analysis (1974) and by the National Planning Association (Lee, et al, 1976) should also be cited as data sources, since they offer complete national sets of data for States and metropolitan areas. As discussed in the text, these projections are economic-based and serve as important reference points for other work.

State and local governmental organizations also provide an important source of new methodology and reference data. A number of States prepare population projections for the State total and for sub-areas such as counties or planning districts. Local jurisdictions develop useful basic data and methodology in working with smaller areas. A survey of this activity was carried out in 1969 and is currently being updated and extended by the Census Bureau.

New methodology and sets of projections are also developed by research centers and by consulting firms, sometimes with financial support from State or Federal agencies. Along with the work by State and local planners, these form an important addition to the data available for use in the preparation of population projections and for reference.

Exhibit 4-A. Selected List of Data Sources

Bowles, Gladys, and James D. Tarver. 1965. "Net Migration of the Population, 1950-60, by Age, Sex, and Color." Economic Research Service, U.S. Department of Agriculture, Washington, D.C.: U.S. Government Printing Office.

Bowles, Gladys, Calvin L. Beale, and Everett S. Lee. 1975. "Net Migration of the Population, 1960-70, by Age, Sex, and Color. United States, Regions, Divisions, States, and Counties." **Population-Migration Report 1960-70 Parts 1-6**. Athens, Georgia: Economic Research Service, U.S. Department of Agriculture; The Institute for Behavioral Research, University of Georgia; Research Applied to National Needs, National Science Foundation, in cooperation.

Lee, Everett S., Ann R. Miller, Richard A. Easterlin, and Carol P. Brainerd. 1957. "Population Redistribution and Economic Growth, United States 1870-1950. Vol. I, Methodological Considerations and Reference Tables." Philadelphia, Pennsylvania: American Philosophical Society.

Lee, Joe W., Timothy B. Sivia, and David W. Fay. **1976 Regional Economic Projections Series** Report 76-R-1 (by subscription only) "States and Large Metropolitan Areas." Washington, D.C.: National Planning Association, 1976.

U.S. Bureau of the Census. 1947a to present. **Current Population Reports**, Series P-20, "Population Characteristics." Washington, D.C.: U.S. Government Printing Office.

_______. 1947b to present. **Current Population Reports**, Series P-25, "Population Estimates and Projections." Washington, D.C.: U.S. Government Printing Office.

_______. 1948 to present. **Current Population Reports**, Series P-60, "Consumer Income." Washington, D.C.: U.S. Government Printing Office.

_______. 1964. Census of Population: 1960. Vol. I, **Characteristics of the Population.** Washington, D.C.: U.S. Government Printing Office.

_______. 1969 to present. **Current Population Reports**, Series P-26, "Federal-State Cooperative Program for Population Estimates." Washington, D.C.: U.S. Government Printing Office.

_______. 1971. **Current Population Reports**, Series P-25, No. 461. "Components of Population Change by County: 1960 to 1970." Washington, D.C.: U.S. Government Printing Office.

_______. 1972a. Census of Population: 1970. Vol. I, **Characteristics of the Population.** Washington, D.C.: U.S. Government Printing Office.

_______. 1972b. Census of Population: 1970. **Subject Reports**, PC(2)-2E, "Migration between State Economic Areas." Washington, D.C.: U.S. Government Printing Office.

_______. 1972c. Census of Population and Housing: 1970. **Census Tracts**. Series PHC (1). Washington, D.C.: U.S. Government Printing Office.

_______. 1973a. Census of Population: 1970. **Subject Reports**, PC(2)-2C, "Mobility for Metropolitan Areas." Washington, D.C.: U.S. Government Printing Office.

_______. 1973b. Census of Population: 1970. **Subject Reports**, PC(2)-2B. "Mobility for States and the Nation." Washington, D.C.: U.S. Government Printing Office.

_______. 1974. **Bureau of the Census Catalog of Publications: 1790-1972.** Washington, D.C.: U.S. Government Printing Office.

_______. 1975a. "Adjusted 1970 Population by Race, Sex, and Age for States and Counties." These adjustments (1) compensate for errors in the census tabulations of centenarians and of nonspecified races, and (2) provide estimated age-race-sex distributions for corrections that change the county total. Serial No. P: D40, Data User Services Division, U.S. Bureau of the Census, Washington, D.C. 20233.

Exhibit 4-A. Selected List of Data Sources—Continued

_______. 1975b. **Current Population Reports**, Series P-25, No 601. "Projections of the Population of the United States: 1975 to 2050." Washington, D.C.: U.S. Government Printing Office.

_______. 1975c. **Current Population Reports**, Series P-20, No. 285. "Mobility of the Population of the United States: March 1970 to March 1975." Washington, D.C.: U.S. Government Printing Office.

_______. 1975d. **Historical Statistics of the United States. Colonial Times to 1970.** Bicentennial Edition. Washington, D.C.: U.S. Government Printing Office.

U.S. Bureau of Economic Analysis, Department of Commerce. 1974. "Area Economic Projections 1990." Washington, D.C.: U.S. Government Printing Office.

U.S. National Center for Health Statistics. 1952 to present. **Monthly Vital Statistics Report.** Washington, D.C.: U.S. Department of Health, Education and Welfare.

_______. 1975a. "1975 Directory, Registration Areas, United States and Canada—Health Officers, Registrars, Principal Statisticians and Research Directors." Washington, D.C.: U.S. Government Printing Office.

_______. 1975b. **Vital Statistics of the United States, 1973.** Vol. II, Part B, "Mortality." Washington, D.C.: U.S. Government Printing Office.

_______. 1975c. **Vital Statistics of the United States, 1972.** Vol. I, "Natality." Washington, D.C.: U.S. Government Printing Office.

_______. 1976. **Vital Statistics of the United States, 1972.** Vol. II, Part A, "Mortality." Washington, D.C.: U.S. Government Printing Office.

U.S. Social Security Administration. 1974. **Actuarial Study No. 72,** Report No. 75-11518, "United States Population Projections for OASDHI Cost Estimates." Washington, D.C.,: U.S. Department of Health, Education and Welfare.

Exhibit 4-B. List of State and Territory Offices Responsible for Vital Statistics Tabulations

(Taken from the 1975 **Directory of Registration Areas, United States and Canada,** National Center for Health Statistics. Updated November 1975 by telephone survey)

State Registrar and Director
Bureau of Vital Statistics
State Department of Public Health
State Office Building
Montgomery, Alabama 36104

State Registrar of Vital Statistics
Department of Health and Social Services
Pouch "H 02G"
Juneau, Alaska 99811

Registrar
Vital Statistics Section
Department of Medical Services
LBJ Tropical Medical Center
Pago Pago, American Samoa 96799

Manager, Vital Records Section
Arizona Department of Health Services
1740 West Adams Street
Phoenix, Arizona 85007

Director, Division of Health Statistics
Arkansas State Department of Health
4815 West Markham Street
Little Rock, Arkansas 72201

Chief, Center for Health Statistics
Department of Health
744 P Street
Sacramento, California 95814

Vital Statistics Clerk
Office of the Health Director
Canal Zone Government
Box M
Balboa Heights, Canal Zone

Chief, Records and Statistics Section
State Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

Chief, Public Health Statistics Section
State Department of Health
79 Elm Street
Hartford, Connecticut 06115

Director, Bureau of Vital Statistics
Department of Health and Social Services
Division of Public Health
Jesse S. Cooper Memorial Building
Federal and Wm. Penn Streets
Dover, Delaware 19901

Chief, Research and Statistics Division
Department of Human Resources
614 H Street, N.W.
Washington, D.C. 20001

Chief, Public Health Statistics Section
Department of Health and Rehabilitative Services
Division of Health
Post Office Box 210
Jacksonville, Florida 32201

Director, Health Services Research and Statistics Section
Division of Physical Health
Department of Human Resources
47 Trinity Avenue, S.W.
Atlanta, Georgia 30334

Territorial Registrar
Office of Vital Statistics
Department of Public Health and Social Services
Government of Guam
Post Office Box 2816
Agana, Guam 96910

State Registrar
Research and Statistics Office
Hawaii Department of Health
Post Office Box 3378
Honolulu, Hawaii 96801

Chief, Bureau of Vital Statistics
Department of Health and Welfare
Statehouse
Boise, Idaho 83720

Director, State Center for Health Statistics
Illinois Department of Public Health
535 West Jefferson Street
Springfield, Illinois 62761

Director, Public Health Statistics
State Board of Health
1330 West Michigan Street
Indianapolis, Indiana 46206

Director, Statistical Services
Division of Records and Statistics
Iowa State Department of Health
Robert Lucas Building
Des Moines, Iowa 50319

Chief, Research and Analysis Branch
Bureau of Registration and Health Statistics
State Department of Health and Environment
6700 South Topeka Avenue
Topeka, Kansas 66620

Supervisor, Health Reports Section
Bureau for Administration and Operations
Department for Human Resources
275 East Main Street
Frankfort, Kentucky 40601

Head, Public Health Statistics
Health and Human Resources Administration
Division of Health
Post Office Box 60630
New Orleans, Louisiana 70160

Director, Division of Research and
Vital Records
Department of Health and Welfare
State House
Augusta, Maine 04333

Chief Statistician
Office of Vital Statistics
Maryland Center for Health Statistics
State Department of Health and Mental Hygiene
201 West Preston Street
Baltimore, Maryland 21201

Director, Office of Health Planning
and Statistics
Massachusetts Department of Public Health
80 Boylston Street
Boston, Massachusetts 02116

Chief, Statistical Services Section
Office of Planning and Evaluation
Michigan Department of Public Health
3500 North Logan Street
Lansing, Michigan 48914

State Demographer
Minnesota State Planning Agency
101 Capitol Square Building
550 Cedar Street
St. Paul, Minnesota 55101

Supervisor, Statistical Services Department
Vital Records Division
State Board of Health
Post Office Box 1700
Jackson, Mississippi 39205

Director, State Center for Health Statistics
Division of Health
Missouri Department of Social Services
Broadway State Office Building
Jefferson City, Missouri 65101

State Registrar
Bureau of Records and Statistics
State Department of Health
Helena, Montana 59601

Director, Division of Health Data and Statistical
Research
State Department of Health
Lincoln Building
1003 O Street
Lincoln, Nebraska 68508

Chief Biostatistician
Section of Vital Statistics
Nevada Division of Health
Department of Human Resources
Capitol Complex
Carson City, Nevada 89710

State Registrar
Bureau of Vital Statistics
Division of Public Health
61 South Spring Street
Concord, New Hampshire 03301

Principal Statistician
Public Health Statistics Program
Division of Laboratories and Epidemiology
State Department of Health
Post Office Box 1540
Trenton, New Jersey 08625

Director, State Health Agency
Health and Social Services Department
State of New Mexico
Post Office Box 2348
Santa Fe, New Mexico 87501

Director of Health Statistics
New York State Department of Health
Empire State Plaza
Tower Building
Albany, New York 12237

Head, Public Health Statistics Branch
Division of Health Services
State Department of Human Resources
Post Office Box 2091
Raleigh, North Carolina 27602

Director, Division of Health Statistics
State Department of Health
State Capitol Building
Bismarck, North Dakota 58505

Chief Statistician
Data Services Unit
Division of Vital Statistics
Ohio Department of Health
266 North Fourth Street
Columbus, Ohio 43215

Director, Public Health Statistics
State Department of Health
N.E. 10th and Stonewall
Post Office Box 53551
Oklahoma City, Oklahoma 73105

Chief Analyst
Vital Statistics Department
Oregon State Health Division
Post Office Box 231
Portland, Oregon 97207

Director, Data Processing Division
Division of Vital Statistics
Pennsylvania Department of Health
700 Health and Welfare Building
Harrisburg, Pennsylvania 17121

Director, Division of Demographic
Registry and Vital Statistics
Puerto Rico Department of Health
Post Office Box 9342
Santurce, Puerto Rico 00908

Chief, Division of Vital Statistics
Rhode Island Department of Health
Health Building
75 Davis Street
Providence, Rhode Island 02908

Assistant State Registrar
Office of Vital Records
South Carolina Department of Health and
Environmental Control
Sims Building
2600 Bull St.
Columbia, South Carolina 29201

Director, Office of Public Health Statistics
State Department of Health
Foss Building
Pierre, South Dakota 57501

Director, Statistical Services
Tennessee Department of Public Health
Room C2-237
Cordell Hull Building
Nashville, Tennessee 37219

Chief, Records and Statistics Section
State Department of Health Resources
410 East Fifth Street
Austin, Texas 78701

Director, Bureau of Statistical Services
Utah State Division of Health
554 South Third East
Salt Lake City, Utah 84111

Chief, Division of Public Health Statistics
Vermont Department of Health
115 Colchester Avenue
Burlington, Vermont 05401

State Registrar
Virginia Health Data Center
James Madison Building
Post Office Box 1000
Richmond, Virginia 23208

Director, Research and Statistical Services
Virgin Islands Department of Health
Charlotte Amalie
St. Thomas, Virgin Islands 00801

Chief Research Analyst
Vital Records Section
Health Services Division
Department of Social and Health Services
Post Office Box 1788, M.S. 50-2
Olympia, Washington 98504

Director, Division of Vital Statistics
State Department of Health
1800 Washington Street
Charleston, West Virginia 25305

Chief, Statistical Services Section
Bureau of Health Statistics
Wisconsin Department of Health and
Social Services
Post Office Box 309
Madison, Wisconsin 53701

Deputy State Registrar
Vital Records Services
Division of Health and Medical Services
Department of Health and Social Services
State Office Building West
Cheyenne, Wyoming 82002

Exhibit 4-C. List of State and Territory Offices Participating in the Federal-State Cooperative Program for Local Population Estimates (September 1976)

Center for Business and Economic Research
Graduate School of Business
University of Alabama
Box AK
University, Alabama 35486

Research and Analysis Section
Alaska Department of Labor
Box 3-7000
Juneau, Alaska 99801

Department of Economic Security
Bureau of Planning
Post Office Box 6123
Phoenix, Arizona 85005

Industrial Research and Extension Center
University of Arkansas
Post Office Box 3017
Little Rock, Arkansas 72203

Population Research Unit
State Department of Finance
1025 P Street
Sacramento, California 95814

Colorado Division of Planning
520 Centennial Building
1313 Sherman Street
Denver, Colorado 80203

Vital Statistics Section
State Health Department
79 Elm Street
Hartford, Connecticut 06115

State Planning Office
Thomas Collins Building
530 South Dupont Highway
Dover, Delaware 19901

Statistical Systems Division
Office of Planning and Management
Room 644 - Munsey Building
1329 E Street, N.W.
Washington, D.C. 20004

Division of Population Studies
Bureau of Economic and Business Research
College of Business Administration
University of Florida
Gainesville, Florida 32611

Office of Planning and Budget
270 Washington Street, S.W.
Atlanta, Georgia 30334

State Department of Health
Post Office Box 3378
Honolulu, Hawaii 96801

Department of Planning and Economic
Development
Post Office Box 2359
Honolulu, Hawaii 96804

Bureau of Vital Statistics
Idaho Department of Health and Welfare
Statehouse
Boise, Idaho 83720

Illinois Department of Public Health
535 West Jefferson Street
Springfield, Illinois 62761

Indiana State Board of Health
1330 West Michigan Street
Indianapolis, Indiana 46206

Planning Support Unit
Office of Planning and Programming
523 East 12th Street
Des Moines, Iowa 50319

Population Research Laboratory
Kansas State University
Manhattan, Kansas 66506

Urban Studies Center
University of Lousiville
Gardencourt Campus
Alta Vista Road
Louisville, Kentucky 40205

Research Division
College of Administration and Business
Louisiana Tech University
Ruston, Louisiana 71270

Research and Vital Records
State Department of Health and Welfare
Augusta, Maine 04330

Maryland Center for Health Statistics
State Department of Health and
Mental Hygiene
O'Connor Building
201 West Preston Street
Baltimore, Maryland 21201

Information Systems Section
Office of the Budget
Michigan Department of Management
and Budget
Lewis Cass Building
Post Office Box 30026
Lansing, Michigan 48909

Minnesota State Planning Agency
101 Capitol Square Building
550 Cedar Street
St. Paul, Minnesota 55101

Department of Sociology
Mississippi State University
Post Office Drawer C
State College, Mississippi 39762

Missouri Division of Budget and Planning
State Capitol
Post Office Box 809
Jefferson City, Missouri 65101

Bureau of Business and Economic Research
University of Montana
Missoula, Montana 59801

Bureau of Business Research
The University of Nebraska
Lincoln, Nebraska 68508

Bureau of Business and Economic Research
University of Nevada
Reno, Nevada 89507

Office of Comprehensive Planning
Executive Department
State House Annex
Concord, New Hampshire 03301

Office of Business Economics
Room 1007
Division of Planning and Research
Department of Labor and Industry
Post Office Box 845
Trenton, New Jersey 08625

Bureau of Business and Economic Research
The University of New Mexico
Albuquerque, New Mexico 87131

New York State Economic Development Board
AESOB - 17th Floor
Post Office Box 7027
Albany, New York 12225

Office of State Planning
North Carolina Department of Administration
116 West Jones Street
Raleigh, North Carolina 27603

Division of Health Statistics
Department of Health
17th Floor
Capitol Building
Bismarck, North Dakota 58505

Office of Research
Department of Economic and
Community Development
State Office Tower
30 East Broad Street
Columbus, Ohio 43215

Research and Planning Division
Oklahoma Employment Security Commission
310 Will Rogers Building
Oklahoma City, Oklahoma 73105

Center for Population Research and Census
Portland State University
Box 751
Portland, Oregon 97207

Office of State Planning and Development
Post Office Box 1323
Harrisburg, Pennsylvania 17120

Puerto Rico Planning Board
Minillas Government Center
North Building, De Diego Avenue
Post Office Box 9447
Santurce, Puerto Rico 00908

Statewide Planning Program
Room 201
265 Melrose Street
Providence, Rhode Island 02907

Division of Research and Statistical Services
South Carolina Budget and Control Board
1026 Sumter Street
Columbia, South Carolina 29201

Public Health Statistics
State Department of Health
Pierre, South Dakota 57501

Tennessee State Planning Office
Division of State Planning
660 Capitol Hill Building
301 Seventh Avenue, North
Nashville, Tennessee 37219

Utah Department of Employment Security
174 Social Hall Avenue
Salt Lake City, Utah 84111

Division of Public Health Statistics
State Department of Health
115 Colchester Avenue
Burlington, Vermont 05401

Tayloe Murphy Institute
Graduate School of Business Administration
University of Virginia
Post Office Box 6550
Charlottesville, Virginia 22906

Population Studies Division
Office of Program Planning and Fiscal Management
House Office Building
Olympia, Washington 98504

Office of Research and Development
Center for Extension and Continuing Education
West Virginia University
Morgantown, West Virginia 26505

Bureau of Health Statistics
State Division of Health
Post Office Box 309
Madison, Wisconsin 53701

Division of Business and Economic Research
College of Commerce and Industry
University of Wyoming
University Station - Box 3925
Laramie, Wyoming 82071

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APPENDIXES

APPENDIX A

Table A-1. Life Table Survival Rates by Age, Race, and Sex, for the United States: 1960 to 1970

(Derived from the official life table for 1965 prepared by the National Center for Health Statistics)

Line No.	Age of cohort: Age in 1960	Age of cohort: Age in 1970	All races: Male (1)	All races: Female (2)	White: Male (3)	White: Female (4)	Black: Male (5)	Black: Female (6)
1	All ages, total.........	All ages, total.	(X)	(X)	(X)	(X)	(X)	(X)
2	Born April 1, 1965-70...	0 to 4 years....	.9713	.9776	.9747	.9807	.9541	.9625
3	Born April 1, 1960-65...	5 to 9 years....	.9673	.9744	.9711	.9779	.9478	.9570
4	0 to 4 years............	10 to 14 years..	.9936	.9952	.9942	.9957	.9903	.9922
5	5 to 9 years............	15 to 19 years..	.9932	.9964	.9935	.9967	.9914	.9950
6	10 to 14 years..........	20 to 24 years..	.9873	.9948	.9879	.9952	.9830	.9921
7	15 to 19 years..........	25 to 29 years..	.9826	.9930	.9840	.9938	.9718	.9871
8	20 to 24 years..........	30 to 34 years..	.9812	.9909	.9837	.9925	.9620	.9801
9	25 to 29 years..........	35 to 39 years..	.9779	.9871	.9814	.9896	.9510	.9698
10	30 to 34 years..........	40 to 44 years..	.9691	.9810	.9734	.9844	.9333	.9557
11	35 to 39 years..........	45 to 49 years..	.9528	.9716	.9578	.9758	.9086	.9383
12	40 to 44 years..........	50 to 54 years..	.9250	.9576	.9307	.9626	.8738	.9152
13	45 to 49 years..........	55 to 59 years..	.8826	.9380	.8888	.9444	.8247	.8805
14	50 to 54 years..........	60 to 64 years..	.8249	.9097	.8315	.9183	.7631	.8285
15	55 to 59 years..........	65 to 69 years..	.7474	.8649	.7550	.8760	.6720	.7531
16	60 to 64 years..........	70 to 74 years..	.6505	.7969	.6584	.8078	.5679	.6788
17	65 and over.............	75 and over.....	.3760	.4513	.3738	.4505	.4062	.4715

X Not applicable.

Table A-2. Projected Life Table Survival Rates by Age, Race, and Sex, for the United States: 1970 to 1980

(Consistent with national projections in Current Population Reports, Series P-25, No. 601)

Line No.	Age of cohort: Age in 1970	Age of cohort: Age in 1980	All races: Male (1)	All races: Female (2)	White: Male (3)	White: Female (4)	Black: Male (5)	Black: Female (6)
1	All ages, total.........	All ages, total.	(X)	(X)	(X)	(X)	(X)	(X)
2	Born April 1, 1975-80...	0 to 4 years....	.9782	.9830	.9804	.9850	.9666	.9728
3	Born April 1, 1970-75...	5 to 9 years....	.9732	.9796	.9765	.9820	.9578	.9671
4	0 to 4 years............	10 to 14 years..	.9937	.9956	.9947	.9960	.9889	.9935
5	5 to 9 years............	15 to 19 years..	.9930	.9963	.9934	.9966	.9912	.9950
6	10 to 14 years..........	20 to 24 years..	.9858	.9946	.9866	.9950	.9784	.9917
7	15 to 19 years..........	25 to 29 years..	.9805	.9929	.9823	.9938	.9687	.9875
8	20 to 24 years..........	30 to 34 years..	.9800	.9914	.9827	.9927	.9604	.9829
9	25 to 29 years..........	35 to 39 years..	.9782	.9884	.9816	.9901	.9511	.9758
10	30 to 34 years..........	40 to 44 years..	.9704	.9828	.9747	.9854	.9357	.9648
11	35 to 39 years..........	45 to 49 years..	.9546	.9737	.9599	.9771	.9127	.9492
12	40 to 44 years..........	50 to 54 years..	.9279	.9600	.9340	.9644	.8797	.9270
13	45 to 49 years..........	55 to 59 years..	.8878	.9410	.8944	.9464	.8303	.8948
14	50 to 54 years..........	60 to 64 years..	.8328	.9140	.8398	.9210	.7689	.8511
15	55 to 59 years..........	65 to 69 years..	.7592	.8767	.7662	.8851	.6891	.7949
16	60 to 64 years..........	70 to 74 years..	.6622	.8183	.6686	.8262	.5948	.7319
17	65 and over.............	75 and over.....	.3940	.4909	.3917	.4901	.4189	.4974

X Not applicable.

Table A-3. Projected Life Table Survival Rates by Age, Race, and Sex, for the United States: 1980 to 1990

(Consistent with national projections in Current Population Reports, Series P-25, No. 601)

Line No.	Age of cohort		All races		White		Black	
	Age in 1980	Age in 1990	Male (1)	Female (2)	Male (3)	Female (4)	Male (5)	Female (6)
1	All ages, total.........	All ages, total.	(X)	(X)	(X)	(X)	(X)	(X)
2	Born April 1, 1985-90...	0 to 4 years....	.9823	.9862	.9837	.9874	.9740	.9793
3	Born April 1, 1980-85...	5 to 9 years....	.9776	.9828	.9798	.9845	.9656	.9738
4	0 to 4 years............	10 to 14 years..	.9941	.9958	.9949	.9962	.9897	.9943
5	5 to 9 years............	15 to 19 years..	.9930	.9964	.9933	.9966	.9915	.9953
6	1 to 14 years..........	20 to 24 years..	.9853	.9946	.9862	.9951	.9808	.9922
7	15 to 19 years..........	25 to 29 years..	.9800	.9932	.9816	.9939	.9696	.9888
8	20 to 24 years..........	30 to 34 years..	.9800	.9919	.9824	.9929	.9631	.9855
9	25 to 29 years..........	35 to 39 years..	.9787	.9892	.9817	.9905	.9555	.9800
10	30 to 34 years..........	40 to 44 years..	.9720	.9842	.9755	.9860	.9426	.9717
11	35 to 39 years..........	45 to 49 years..	.9571	.9756	.9614	.9780	.9219	.9584
12	40 to 44 years..........	50 to 54 years..	.9317	.9625	.9369	.9660	.8906	.9381
13	45 to 49 years..........	55 to 59 years..	.8922	.9437	.8984	.9482	.8427	.9089
14	50 to 54 years..........	60 to 64 years..	.8391	.9180	.8456	.9237	.7829	.8710
15	55 to 59 years..........	65 to 69 years..	.7673	.8846	.7736	.8914	.7058	.8228
16	60 to 64 years..........	70 to 74 years..	.6719	.8325	.6770	.8384	.6157	.7647
17	65 and over.............	75 and over.....	.4096	.5134	.4076	.5125	.4298	.5139

X Not applicable.

APPENDIX B

Table B-1. National Census Survival Rates by Age, Race, and Sex, for the United States: 1960 to 1970

(Based on the total resident population, plus Armed Forces overseas, adjusted to exclude net civilian immigration during the decade)

Line No.	Age of cohort: Age in 1960	Age of cohort: Age in 1970	All races: Male (1)	All races: Female (2)	White: Male (3)	White: Female (4)	Black: Male (5)	Black: Female (6)
1	All ages, total.........	All ages, total.	(X)	(X)	(X)	(X)	(X)	(X)
2	Born April 1, 1965-70...	0 to 4 years[1]...	.9463	.9568	.9605	.9701	.8755	.8922
3	Born April 1, 1960-65...	5 to 9 years[1]...	.9439	.9534	.9522	.9610	.8996	.9141
4	0 to 4 years...........	10 to 14 years..	1.0053	1.0006	1.0020	.9970	1.0251	1.0211
5	5 to 9 years...........	15 to 19 years..	1.0061	1.0083	1.0052	1.0069	1.0119	1.0170
6	10 to 14 years..........	20 to 24 years..	.9841	.9979	.9889	.9979	.9500	.9982
7	15 to 19 years..........	25 to 29 years..	.9688	.9929	.9732	.9886	.9366	1.0234
8	20 to 24 years..........	30 to 34 years..	.9860	1.0026	.9847	.9963	.9962	1.0455
9	25 to 29 years..........	35 to 39 years..	.9790	.9957	.9801	.9938	.9705	1.0082
10	30 to 34 years..........	40 to 44 years..	.9697	.9872	.9718	.9889	.9515	.9748
11	35 to 39 years..........	45 to 49 years..	.9437	.9632	.9483	.9678	.9045	.9258
12	40 to 44 years..........	50 to 54 years..	.9290	.9602	.9326	.9644	.8961	.9244
13	45 to 49 years..........	55 to 59 years..	.8806	.9338	.8852	.9394	.8389	.8846
14	50 to 54 years..........	60 to 64 years..	.8439	.9336	.8455	.9356	.8286	.9141
15	55 to 59 years..........	65 to 69 years..	.7527	.8943	.7505	.8914	.7740	.9222
16	60 to 64 years..........	70 to 74 years..	.6776	.8358	.6747	.8367	.7093	.8255
17	65 and over.............	75 and over.....	.3899	.5075	.3893	.5094	.3962	.4833

X Not applicable. [1]Based on registered births.

Table B-2. Projected National Census Survival Rates by Age, Race, and Sex, for the United States: 1970 to 1980

(Based on the total resident population, plus Armed Forces overseas. Consistent with national projections in Current Population Reports, Series P-25, No. 601)

Line No.	Age of cohort: Age in 1970	Age of cohort: Age in 1980	All races: Male (1)	All races: Female (2)	White: Male (3)	White: Female (4)	Black: Male (5)	Black: Female (6)
1	All ages, total.........	All ages, total.	(X)	(X)	(X)	(X)	(X)	(X)
2	Born April 1, 1975-80...	0 to 4 years[1]...	.9531	.9620	.9662	.9744	.8869	.9017
3	Born April 1, 1970-75...	5 to 9 years[1]...	.9487	.9575	.9571	.9647	.9041	.9186
4	0 to 4 years...........	10 to 14 years..	1.0157	1.0166	1.0067	1.0061	1.0631	1.0699
5	5 to 9 years...........	15 to 19 years..	1.0105	1.0180	1.0053	1.0135	1.0375	1.0419
6	10 to 14 years..........	20 to 24 years..	.9681	.9912	.9731	.9923	.9288	.9820
7	15 to 19 years..........	25 to 29 years..	.9330	.9661	.9463	.9898	.8429	.9409
8	20 to 24 years..........	30 to 34 years..	.9561	.9822	.9652	.9826	.8985	.9806
9	25 to 29 years..........	35 to 39 years..	.9773	1.0067	.9852	1.0089	.9260	.9933
10	30 to 34 years..........	40 to 44 years..	.9755	.9993	.9818	1.0036	.9204	.9678
11	35 to 39 years..........	45 to 49 years..	.9683	.9759	.9659	.9791	.9719	.9464
12	40 to 44 years..........	50 to 54 years..	.9509	.9649	.9489	.9693	.9594	.9276
13	45 to 49 years..........	55 to 59 years..	.9047	.9335	.9081	.9398	.8748	.8803
14	50 to 54 years..........	60 to 64 years..	.8362	.8917	.8383	.8961	.8182	.8563
15	55 to 59 years..........	65 to 69 years..	.7826	.9210	.7851	.9091	.8578	.9794
16	60 to 64 years..........	70 to 74 years..	.6803	.8444	.6866	.8505	.6836	.7706
17	65 and over.............	75 and over.....	.4189	.5495	.4111	.5469	.4208	.5154

X Not applicable. [1]Based on births not adjusted for underregistration.

Table B-3. Projected National Census Survival Rates by Age, Race, and Sex, for the United States: 1980 to 1990

(Based on the total resident population, plus Armed Forces overseas. Consistent with national projections in Current Population Reports, Series P-25, No. 601)

Line No.	Age of cohort: Age in 1980	Age of cohort: Age in 1990	All races: Male (1)	All races: Female (2)	White: Male (3)	White: Female (4)	Black: Male (5)	Black: Female (6)
1	All ages, total.........	All ages, total.	(X)	(X)	(X)	(X)	(X)	(X)
2	Born April 1, 1985-90...	0 to 4 years[1]...	.9570	.9651	.9694	.9768	.8937	.9077
3	Born April 1, 1980-85...	5 to 9 years[1]...	.9529	.9607	.9603	.9671	.9115	.9250
4	0 to 4 years...........	10 to 14 years..	1.0161	1.0168	1.0069	1.0063	1.0640	1.0707
5	5 to 9 years...........	15 to 19 years..	1.0105	1.0181	1.0053	1.0135	1.0378	1.0422
6	10 to 14 years..........	20 to 24 years..	.9677	.9913	.9726	.9923	.9311	.9825
7	15 to 19 years..........	25 to 29 years..	.9325	.9664	.9457	.9899	.8437	.9421
8	20 to 24 years..........	30 to 34 years..	.9561	.9827	.9650	.9828	.9011	.9832
9	25 to 29 years..........	35 to 39 years..	.9778	1.0075	.9854	1.0093	.9303	.9975
10	30 to 34 years..........	40 to 44 years..	.9771	1.0007	.9826	1.0042	.9271	.9748
11	35 to 39 years..........	45 to 49 years..	.9709	.9778	.9675	.9801	.9817	.9556
12	40 to 44 years..........	50 to 54 years..	.9547	.9674	.9518	.9709	.9713	.9386
13	45 to 49 years..........	55 to 59 years..	.9093	.9362	.9122	.9416	.8878	.8941
14	50 to 54 years..........	60 to 64 years..	.8426	.8956	.8441	.8987	.8332	.8764
15	55 to 59 years..........	65 to 69 years..	.7910	.9293	.7927	.9155	.8787	1.0139
16	60 to 64 years..........	70 to 74 years..	.6902	.8591	.6952	.8631	.7077	.8051
17	65 and over.............	75 and over.....	.4356	.5747	.4278	.5719	.4318	.5326

X Not applicable.
[1]Based on births not adjusted for underregistration.

APPENDIX C

DERIVATION OF SURVIVAL RATES FROM A LIFE TABLE

This section describes techniques for calculating survival rates from an abridged life table. Such a table for the United States, representing the year 1965, is shown in table C-1. This table was developed by the National Center for Health Statistics, Department of Health, Education and Welfare, and was published in the Mortality volume, Part A, for that year.

Table C-1. Abridged Life Table for White Females for the United States: 1965

Age interval	Proportion dying	Of 100,000 born alive		Stationary population		Average remaining lifetime
Period of life between two exact ages stated in years	Proportion of persons alive at beginning of age interval dying during interval	Number living at beginning of age interval	Number dying during age interval	In the age interval	In this and all subsequent age intervals	Average number of years of life remaining at beginning of age interval
(1)	(2)	(3)	(4)	(5)	(6)	(7)
x to x + n	$_nq_x$	ℓ_x	$_nd_x$	$_nL_x$	T_x	$\mathring{e}_x$
WHITE FEMALE						
0 to 1	0.0183	100,000	1,834	98,378	7,468,335	74.7
1 to 5	.0029	98,166	287	391,978	7,369,957	75.1
5 to 10	.0017	97,879	164	488,948	6,977,979	71.3
10 to 15	.0014	97,715	137	488,250	6,489,031	66.4
15 to 20	.0025	97,578	244	487,313	6,000,781	61.5
20 to 25	.0032	97,334	308	485,918	5,513,468	56.6
25 to 30	.0035	97,026	343	484,305	5,027,550	51.8
30 to 35	.0051	96,683	490	482,260	4,543,245	47.0
35 to 40	.0075	96,193	725	479,278	4,060,985	42.2
40 to 45	.0117	95,468	1,117	474,750	3,581,707	37.5
45 to 50	.0185	94,351	1,745	467,690	3,106,957	32.9
50 to 55	.0277	92,606	2,561	456,988	2,639,267	28.5
55 to 60	.0407	90,045	3,661	441,671	2,182,279	24.2
60 to 65	.0607	86,384	5,245	419,666	1,740,608	20.1
65 to 70	.0988	81,139	8,015	386,885	1,320,942	16.3
70 to 75	.1540	73,124	11,263	339,016	934,057	12.8
75 to 80	.2464	61,861	15,241	272,734	595,041	9.6
80 to 85	.3888	46,620	18,124	187,629	322,307	6.9
85 and over	1.0000	28,496	28,496	134,678	134,678	4.7

Source: U.S. National Center for Health Statistics, Vital Statistics of the United States, 1965. Vol. II, Part A, Mortality.

A life table is based on actual death statistics and can be used to calculate a survival rate suitable for use in a cohort component population computation. Some life tables give figures for each single year of age. The abridged life table shown in table C-1 shows 5-year age groups, the same as are used in the projections illustrated in Appendix H.

All but three of the needed survival rates are obtained from the column of the life table labeled L_x. This column (with T_x) is often called the "Stationary Population" and may be thought of as the actual population that would evolve in a closed geographic area where 100,000 persons are born each year, these persons being subject to a fixed mortality schedule throughout their life span. In an abridged life table the subscript x in ${}_nL_x$ is a variable delimiting the lower limit of an age group and the subscript n indicates the number of years of age in the group. Thus, ${}_5L_{15}$ represents the stationary population from age 15 to, but not including 20 years of age. Ten years later the survivors of this group would be labeled ${}_5L_{25}$.

It follows that the survival rate for this 5-year cohort for 10 years of time is simply ${}_5L_{25}$ divided by ${}_5L_{15}$ or .993827 in this life table. A survival rate for the same cohort for a 5-year time period would be ${}_5L_{20}$ divided by ${}_5L_{15}$ or .997137.

The youngest and oldest age groups require special procedures. To begin with the youngest group, the life table assumes 100,000 births per year (the value labeled l_o; some tables show 10,000), and for 5 successive years of time this will sum to 500,000 written as ${}_5l_o$. The table shows that of these births, 490,356 still survive at the end of the 5-year period, written as ${}_5L_o$. (It is customary to show a single year of age for the youngest group labeled L_o, followed by a 4-year group, labeled ${}_4L_1$. Adding these two figures gives ${}_5L_o$.) Dividing 490,356 by 500,000 gives .980712, which is the required survival rate for a 5-year period. A special case arises if the time unit of the projections is 10 years as with the illustrative method shown in Appendix H. In this case a survival rate is needed for the population aged 5 to 9 years at the end of the period, being the cohort which was born during the first 5 years of the decade. To calculate this rate, divide ${}_5L_5$ by ${}_5l_o$. In table C-1, this will be 488,948÷500,000, or .977896. The survival rate for the births occurring in the second half of the decade is .980712, as calculated above.

The survival rate for the terminal age group (the oldest group, which includes all persons of a certain specified age and over) is calculated from the column labeled T_x. The values in this column represent the total number of persons of age x and above (the T_x value is calculated as the sum of all L_x values for age x and above). The survival rate for the age group 65 years and over becoming 75 years and over 10 years later is therefore $T_{75} \div T_{65}$ or .450467.

APPENDIX D

Table D-1. State Factors for Estimating County Population on July 1, 1970 by Extrapolation from Census Data

(See text for explanation of method)

State	Extrapolation factors		State	Extrapolation factors	
	1970 census factor (f_1)	1960 census factor (f_2)		1970 census factor (f_1)	1960 census factor (f_2)
Alabama	1.025636	.025016	Montana	1.028977	.025097
Alaska	1.025758	.025018	Nebraska	1.026950	.025048
Arizona	1.029629	.025113	Nevada	1.023850	.024972
Arkansas	1.027733	.025067	New Hampshire	1.026422	.025035
California	1.022348	.024935	New Jersey	1.024671	.024992
Colorado	1.027137	.025052	New Mexico	1.030809	.025142
Connecticut	1.023871	.024972	New York	1.024464	.024987
Delaware	1.024820	.024996	North Carolina	1.025640	.025016
Dist. of Columbia	1.024921	.024998	North Dakota	1.028689	.025090
Florida	1.026871	.025046	Ohio	1.023847	.024972
Georgia	1.025381	.025009	Oklahoma	1.025940	.025023
Hawaii	1.026207	.025029	Oregon	1.025646	.025016
Idaho	1.030199	.025127	Pennsylvania	1.025603	.025015
Illinois	1.023959	.024975	Rhode Island	1.023896	.024973
Indiana	1.024111	.024978	South Carolina	1.025673	.025016
Iowa	1.026964	.025048	South Dakota	1.027712	.025066
Kansas	1.024300	.024983	Tennessee	1.026089	.025027
Kentucky	1.027206	.025054	Texas	1.024923	.024998
Louisiana	1.024780	.024995	Utah	1.027627	.025064
Maine	1.027528	.025062	Vermont	1.025659	.025016
Maryland	1.023636	.024967	Virginia	1.023484	.024963
Massachusetts	1.025569	.025014	Washington	1.022098	.024929
Michigan	1.023704	.024968	West Virginia	1.030681	.025139
Minnesota	1.025056	.025001	Wisconsin	1.024783	.024995
Mississippi	1.026157	.025028	Wyoming	1.029162	.025102
Missouri	1.025340	.025008			

APPENDIX E

Table E-1. Estimated and Projected General Fertility Rates by Race, for the United States: 1970 to 1990

(Annual births per 1,000 women aged 15-44 years)

Year or period	All races	White	Black[1]
ESTIMATES			
1970 (calendar year)[2]	87.5	83.5	113.8
PROJECTIONS			
Series I			
July 1, 1970-75	74.8	70.7	100.8
July 1, 1975-80	83.5	80.3	102.1
July 1, 1980-85	92.7	91.3	100.4
July 1, 1985-90	93.9	93.6	95.5
Series II			
July 1, 1970-75	73.9	70.0	99.1
July 1, 1975-80	72.2	68.8	92.3
July 1, 1980-85	76.5	74.5	87.5
July 1, 1985-90	74.4	73.2	80.2
Series III			
July 1, 1970-75	73.4	69.3	99.1
July 1, 1975-80	62.8	59.6	82.0
July 1, 1980-85	63.9	61.9	74.8
July 1, 1985-90	60.6	59.3	67.1

[1] Includes, in addition to the Black population, all races other than White.

[2] Differs from the rates published by the U.S. National Center for Health Statistics (NCHS) in that the July 1, 1970 population is the base for computation, rather than the April 1, 1970 census population used by the NCHS.

Source: U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 601. "Projections of the Population of the United States: 1975 to 2050." In some cases, the 5-year general fertility rates (GFR's) shown here differ slightly from the 5-year GFR's in Series P-25, No. 601, table A-8, which represent averages of GFR's for single years.

APPENDIX F

Table F-1. Cohort-Size Adjustment Factors for Interpolation to July 1, 1975, from Population for July 1, 1970 and 1980

(Calculated from national population estimates and projections, U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 601; by formula, $f = P_x^{1975} \div 1/2\ (P_x^{1970} + P_x^{1980})$ where f is the adjustment factor, P is population, and x is any 5-year age group)

Age	All races		White		Black	
	Male	Female	Male	Female	Male	Female
0 to 4 years...........	.9327	.9313	.9237	.9219	.9764	.9753
5 to 9 years...........	.9656	.9676	.9652	.9666	.9678	.9722
10 to 14 years.........	1.0606	1.0600	1.0599	1.0601	1.0645	1.0593
15 to 19 years.........	1.0563	1.0575	1.0555	1.0567	1.0612	1.0620
20 to 24 years.........	1.0139	1.0142	1.0127	1.0112	1.0215	1.0323
25 to 29 years.........	1.0429	1.0442	1.0502	1.0489	.9963	1.0156
30 to 34 years.........	.9785	.9803	.9782	.9801	.9804	.9812
35 to 39 years.........	.9252	.9316	.9225	.9289	.9434	.9487
40 to 44 years.........	.9539	.9459	.9477	.9395	.9971	.9882
45 to 49 years.........	1.0205	1.0206	1.0204	1.0199	1.0215	1.0257
50 to 54 years.........	1.0489	1.0566	1.0511	1.0600	1.0313	1.0294
55 to 59 years.........	.9900	.9907	.9930	.9929	.9644	.9722
60 to 64 years.........	1.0059	1.0041	1.0049	1.0028	1.0152	1.0159
65 years and over......	.9996	1.0036	.9988	1.0036	1.0083	1.0026

Table F-2. Cohort-Size Adjustment Factors for Interpolation to July 1, 1985, from Population for July 1, 1980 and 1990

(Calculated from national population estimates and projections, U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 601; by formula, $f = P_x^{1985} \div 1/2\ (P_x^{1980} + P_x^{1990})$ where f is the adjustment factor, P is population, and x is any 5-year age group)

Age	All races		White		Black	
	Male	Female	Male	Female	Male	Female
0 to 4 years...........	1.0591	1.0590	1.0654	1.0654	1.0285	1.0286
5 to 9 years...........	.9667	.9663	.9585	.9584	1.0064	1.0034
10 to 14 years.........	.9293	.9282	.9215	.9195	.9666	.9682
15 to 19 years.........	.9619	.9636	.9622	.9634	.9604	.9648
20 to 24 years.........	1.0564	1.0558	1.0563	1.0566	1.0567	1.0518
25 to 29 years.........	1.0523	1.0524	1.0521	1.0530	1.0536	1.0489
30 to 34 years.........	1.0095	1.0077	1.0093	1.0070	1.0111	1.0122
35 to 39 years.........	1.0374	1.0381	1.0459	1.0448	.9817	.9972
40 to 44 years.........	.9746	.9762	.9756	.9775	.9673	.9679
45 to 49 years.........	.9225	.9283	.9209	.9266	.9337	.9394
50 to 54 years.........	.9516	.9428	.9461	.9370	.9910	.9822
55 to 59 years.........	1.0187	1.0182	1.0188	1.0179	1.0173	1.0203
60 to 64 years.........	1.0471	1.0547	1.0496	1.0586	1.0259	1.0230
65 years and over......	.9973	.9985	.9982	.9991	.9889	.9921

APPENDIX G

LABOR FORCE EVALUATION

Having obtained population projections by age, race, and sex, an evaluation by means of the labor force implied by the data helps to determine the reasonableness of the projections. This evaluation can be carried out by using labor force participation rates to calculate a projected labor force consistent with the population projections. This labor force is then compared with current employment statistics. This section describes in general terms the preparation of the data and presents the results of the analysis in table G-1.

The procedure in this evaluation was to (1) note the labor force participation rates by age, race, and sex for "Tri-county Area, USA" in the 1970 census, (2) project these rates to 1980 by comparison with projections for the Nation, and (3) project a labor force for 1980 by multiplying these rates by the population projections for the area. The population projections (not shown) were obtained in the manner described in the final three paragraphs of Appendix H. Since the labor force projections are by age, race, and sex, the computation automatically allows for changes in the 1970 and 1980

Table G-1. Estimated and Projected Population and Labor Force by Sex, "Tri-county Area, USA", and the United States: July 1, 1970, 1974 and 1980

(Population and labor force in thousands)

Line No.	Area, labor force status and sex	1970	1974	1980	Average annual percent change	
					1970-74	1970-80
	"TRI-COUNTY AREA, USA"					
	All Classes					
1	Population......................	337.8	362.0	398.1	1.7	1.7
2	Labor force.....................	133.1	151.6	179.6	3.3	3.0
3	Employment.....................	101.4	116.1	(NA)	3.4	(NA)
	Males					
4	Population......................	171.2	184.4	204.1	1.9	1.8
5	Labor force.....................	89.7	101.8	119.5	3.2	2.9
	Females					
6	Population......................	166.6	177.6	194.0	1.6	1.5
7	Labor force.....................	43.4	49.8	60.1	3.5	3.3
	UNITED STATES					
8	Population[1].......................	204,878	211,894	224,132	0.8	0.9
9	Labor force[2]......................	85,903	93,241	101,809	2.1	1.7

NA Not available.
[1]Total population including the Armed Forces overseas.
[2]Based on the total noninstitutional population.

Sources:
Lines 1 to 7. See text.
Line 8. (1970 and 1974) U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 614, November 1975.
(1980) U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 493, December 1972.
Line 9. (1970 and 1974) U.S. Bureau of Labor Statistics. Employment and Earnings, Vol. 17, No. 7. January 1971, and Vol. 21, No.7, January, 1975.
(1980) Denis F. Johnston. "The U.S. Labor Force: Projections to 1990," Monthly Labor Review, July 1973, or Special Labor Force Report, No. 156, U.S. Bureau of Labor Statistics, 1973.

age-race-sex population structure and differences between the United States structure and that of the local area. The projection of labor force participation rates was very simplistic, however, making the assumption that the ratio of the "Tri-county Area, USA" rates to national rates will be the same in 1980 as it was in 1970. Projections of national rates are subject to error, and the ratio of local area to national rates may change.

After calculating the labor force for 1980, the rate of change from 1970 to 1980 for the total was noted. These data are in table G-1 and show an average annual increase of 3.0 percent for the total labor force, 2.9 percent for males, and 3.3 percent for females. Note that the population is projected to increase much more slowly. This is due to the decrease in growth rates for the population below labor force age and to increased labor force participation rates for young workers, at a time when this group is growing in numbers as a result of the "baby boom" of the 1950's.

As a means of verifying this projected trend, current employment statistics published by the State employment security offices were consulted. The most recent available data were for 1974. Accordingly, the population by age was calculated for 1974 by interpolation between data for 1970 and 1980 (as adjusted in Appendix H for the 1974 postcensal estimate), and labor force participation rates were developed, also by interpolation. Multiplying the two elements gave the labor force for 1974, shown in table G-1. The labor force (both sexes) is projected to grow 3.3 percent per year from 1970 to 1974 (line 2).

Current employment is generally not available by age or sex for local areas, and in this case only an all classes figure was provided by the State employment security office. Employment is entered in table G-1 on line 3. The average annual change in employment during the period 1970-74 was 3.4 percent, which is close to the projected figure of 3.3 percent for the labor force (line 2). We conclude that this evaluation supports the projected population trend, because of the similarity between the estimated and projected percent of change.[1] The absolute level of employment shown is affected by multiple jobholding and by the fact that place of work, not place of residence, is the basis for compiling employment statistics.

[1]See column 2.

The correspondence between the estimates and projections will not always materialize, and if the difference is great, a reappraisal is in order. The employment data can be examined in the light of the above-mentioned problems, and the projected labor force participation rates reconsidered. The postcensal population estimate, which enters into the comparison, is subject to some error, and the input and assumptions of the projections can be checked. Finally, change in the population of retirement age might have little or no effect on employment.

For comparison, data on population and labor force for the United States are shown on lines 8 and 9 of table G-1. The labor force is shown as growing more rapidly than the population, as was the case for "Tri-county Area, USA", but the growth rates for both population and labor force of the local area are higher than those for the Nation. The projected net in-migration for the area is consistent with this relationship.

Several technical difficulties will be encountered in the preparation of data for labor force evaluation. In "Tri-county Area, USA", one of the counties was officially added to the SMSA after 1970. For this county, the statistics from the 1970 census are in very much less detail. Finer subdivisions of age had to be estimated, requiring considerable staff time.

Another problem involves the classification by race. The population projections are for (1) White, and (2) Black and other races. This dichotomy is useful for local areas, and also was dictated by the type of county data by race and age available in the 1960 census. In the 1970 census volumes however, county labor force data by age are available only for (1) Black, and (2) all other. For the evaluation shown in this section, the 1970 census data were converted to the classification used in the projections by a tedious estimation process.

[1]The rates of change in reported employment and estimated labor force shown in table G-1 are not strictly comparable because the labor force includes members of the Armed Forces and the unemployed. However, the strength of the military bases in the area did not change materially during the 1970-74 period.

APPENDIX H

STEP-BY-STEP ILLUSTRATION OF THE COHORT-COMPONENT PROCEDURE FOR POPULATION PROJECTIONS OF LOCAL AREAS

(The term "Black" as used in this section refers to the population of Black and other races)

1. Introduction

This section provides a detailed explanation of one of the standard methods used in making population projections for local areas, the cohort-component method. Tables H- to H-9 demonstrate the use of the method by projecting the White female population of "Central County, USA" to 1980. This is a fictitious name for a United States county which in fact is the central county of a three-county SMSA. The actual name of the county is not given because the method illustrated here is designed for general use in the United States. The basic method is shown for "Central County" only, but Section 5 in this appendix illustrates the technique of adjusting the projections for the three individual counties to a control projection for the total area (tables H-10 to H-14).

The projection method shown serves two functions. On the one hand, the procedure has been kept as simple as possible, and the inexperienced technician will find all the materials needed to make standard "demographic" projections which rely on the assumption that past trends of net migration will continue. The computations can be carried out on a simple desk calculator. On the other hand, the basic procedure is methodologically sound, within the general limitations of net migration models. If a more sophisticated determination of projected migration trends is available, for example by means of an economic-demographic model, and if corrections for extreme migration rates and special populations are introduced, as mentioned in the text, the method can serve as the demographic framework for a more complex model involving sets of subareas, controlled to an area total.

The cohort-component method illustrated here is especially appropriate for making projections by age, and by sex and race if desired. It is, however, not suitable for very small areas such as census tracts, functioning best when used for metropolitan areas (or other similar grouping of counties) and counties. For subcounty projections, other methods should be employed. See Section 3 (pp. 11-30) for a review of existing methodology, and Section 2.31 for further discussion of the county as a unit for projections.

It should also be understood that the method shown here in a step-by-step format does not specifically take account of the economic prospects of the area. Projections currently being developed by State and local technicians sometimes introduce projections of employment and other economic data. It has not been established that such projections are superior to purely demographic projections in predicting the future total population of a local area. However, it is clearly useful for planning purposes to produce a set of mutually consistent demographic and economic projections.

To achieve such consistency, special adjustments to the demographic projections would be required. One of the important features of the step-by-step method that follows is the method shown for adjusting the preliminary population projections to 1980 to take into account a postcensal population estimate. If economic projections were involved, these same techniques would form a substantial part of an adjustment to make demographic projections consistent with an externally prepared projection of economic data. The adjustments would lead to a final population projection by age, sex, and race perfectly consistent with the externally derived data.

The further adjustment of the individual county projections to agree with a multi-county total is shown in Section 5 of this appendix, which describes the more complex statistical techniques needed to bring into balance the demographic projections by age for the various counties.

2. General Procedure

The basic procedure in the main body of the cohort-component method given below is to project independently the three components of population change (births, deaths, and migration) from 1970 to

1980.[1] Projections for the year 1975 are obtained by a modified interpolation technique (table H-8). The computation is by cohort and provides for detail by age, race, and sex. Complete calculations are shown only for White females, but the results of similar computations for the other three race-sex groups are introduced in some steps as necessary.

Births are projected using the general fertility rate, deaths are taken into account by using survival rates calculated from a life table (See Appendix C), and migration is projected by first calculating residual net migration for the period 1960-70 by the forward survival method, then assuming that the migration rate observed will continue from 1970 to 1980. Important modifications of the migration rate are introduced to take the 1974 postcensal estimate into account; it is the method used to make these modifications which would be used to adjust to an externally derived projection of migration. Finally, the 1975 population (and any other intercensal year) is obtained by interpolation between the 1970 and the 1980 populations.

[1] A fundamental feature of the method presented here is that the projection from 1970 to 1980 is made in one 10-year calculation, not in two 5-year periods. The potential error introduced in the migration component by the latter procedure is discussed in Section 3.234, under Adjacent cohort technique.

Note that this guide provides the background data needed to project the population either by race or not, at the option of the user, by providing data first for all races, then separately for the White and Black populations. The illustration shown below does exercise the option to obtain race detail, recognizing the importance of this factor in analyzing population change in local areas.

3. Step-by-step Instructions

3.1 Computation of net migration by age, 1960-70 (table H-1). Before entering any numbers in column 1, read all the instructions relating to the column.

Column 1. On lines 4 to 17, enter the White female population from the April 1, 1960 census in 5-year age groups. (See Exhibit 4-A, "Selected List of Data Sources", for a complete reference to the 1960 census.) Note that the computation is by cohort, and each line (2 to 17) of the table represents the demographic experience of a cohort from 1960 to 1970. Enter the population 0-4 years of age on line 4 in accord with the labeling of the column "Age in 1960." On line 17, the population 65 and over is entered as the terminal age group, and on line 1, the all ages population is entered.

Table H-1. Computation of Net Migration by Age for White Females by the Forward Survival Method for "Central County, USA": April 1, 1960 to 1970

Line No.	Age of cohort		Population April 1, 1960 and births 1960-70	Life table survival rates	Expected population 1970	Population April 1, 1970	Net migration	
	Age in 1960	Age in 1970	(1)	(2)	(3)=(1)x(2)	(4)	Amount (5)=(4)-(3)	Percent $(6)=\frac{(5)}{(3)}x100$
1	All ages, total.......	All ages, total.....	[1]66,674	(X)	81,409	79,340	-2,069	-2.54
2	Born April 1, 1965-70.	0 to 4 years........	[2](8,945)	.9807	8,772	6,992	-1,780	-20.29
3	Born April 1, 1960-65.	5 to 9 years........	[2](10,099)	.9779	9,876	7,699	-2,177	-22.04
4	0 to 4 years..........	10 to 14 years......	8,626	.9957	8,589	7,781	-808	-9.41
5	5 to 9 years..........	15 to 19 years......	7,178	.9967	7,154	7,143	-11	-0.15
6	10 to 14 years........	20 to 24 years......	6,073	.9952	6,044	8,719	2,675	44.26
7	15 to 19 years........	25 to 29 years......	5,120	.9938	5,088	6,221	1,133	22.27
8	20 to 24 years........	30 to 34 years......	5,450	.9925	5,409	4,851	-558	-10.32
9	25 to 29 years........	35 to 39 years......	4,981	.9896	4,929	4,726	-203	-4.12
10	30 to 34 years........	40 to 44 years......	5,009	.9844	4,931	4,696	-235	-4.77
11	35 to 39 years........	45 to 49 years......	5,231	.9758	5,104	4,831	-273	-5.35
12	40 to 44 years........	50 to 54 years......	4,160	.9626	4,004	3,939	-65	-1.62
13	45 to 49 years........	55 to 59 years......	3,610	.9444	3,409	3,282	-127	-3.73
14	50 to 54 years........	60 to 64 years......	2,982	.9183	2,738	2,733	-5	-0.18
15	55 to 59 years........	65 to 69 years......	2,385	.8760	2,089	2,046	-43	-2.06
16	60 to 64 years........	70 to 74 years......	1,760	.8078	1,422	1,508	86	6.05
17	65 and over...........	75 and over.........	4,109	.4505	1,851	2,173	322	17.40

X Not applicable.
[1]Excluding births. Total including births is 85,718.
[2]Registered births, shown in parentheses to distinguish from population counts.

On line 2, enter births for the period April 1, 1965 to April 1, 1970 to begin the calculation for the cohort 0-4 years of age in 1970. Enter births for the period April 1, 1960 to April 1, 1965 on line 3. Registered births by year for counties, needed to complete lines 2 and 3, are available from each State Health registrar (see Exhibit 4-B). The usual procedure for obtaining these values is to subdivide annual data as needed by straight line interpolation. Thus line 2 can be obtained by adding three-fourths of 1965 births to data for 1966 to 1969, plus one-fourth of 1970 births. Line 3 can be obtained by a similar computation for the period April 1, 1960 to April 1, 1965. It would be preferable to use monthly data, if available.

In footnote 1, enter the total population plus all births for the decade for later use in computing the number of deaths, and to provide a control total for all of the entries in the column. It is recommended that lines 2 and 3 be shown in parentheses as a reminder that these represent births, not population alive in 1960.

Column 2. Enter life table survival rates (LTSR's) for the period 1960 to 1970. Rates for the Nation, derived from a table prepared by the National Center for Health Statistics (NCHS), are given in table A-1 and are used here. These can be used for all U.S. counties, although it would be preferable to use survival rates derived from an appropriate State life table, which are also prepared by NCHS for decennial census years. Sometimes a life table is available for a specific multi-county area. The method of computing survival rates from a life table is illustrated in Appendix C. The national rates are provided for use in case more appropriate rates are not available.[2]

An important alternative to LTSR's is the use of national census survival rates (NCSR). NCSR's calculated for the periods 1960-70 and 1970-80 are given in Appendix B. See Section 3.233 for a discussion of the issues involved in their use as opposed to LTSR's. The technician may substitute these rates for the LTSR's, but whichever type is selected must be used in both periods, 1960-70 and 1970-80. If NCSR's are used, the computation for 1960-70 in table H-1 will yield very similar estimates of net migration to those prepared for all counties by Bowles, Beale, and Lee except that their estimates are adjusted to agree with vital statistics totals.[3] The NCSR's produce census-level population projections, just as do the LTSR's, but the age detail is adjusted by correcting for age differentials in net census undercount at the national level. When NCSR's are used on a local area, the implicit assumption is that the effect of net census undercount on the estimates is the same for the local area as for the Nation.

Column 3. Compute the population "expected" in 1970 in the absence of migration by multiplying column 1 by column 2. Line 1 of column 3 is obtained by addition.

Column 4. Enter the April 1, 1970 census population on lines 2-17. Follow the labeling in the column "Age in 1970." Enter the population 0-4 on line 2 (note that the 5-year age detail extends to 75 and over on line 17). On this line in column 1, the 1960 population aged 65 and over has been entered, being the same cohort.

Column 5. The difference between the census population and the expected population is assumed to be net migration (census minus expected). This is sometimes referred to as "residual" net migration, and in addition to migration, implicitly reflects the net result of errors in the census counts and in the estimates of births and survival rates used.[4] A minus sign indicates net out-migration, as the expected population is greater than the census count. These results show an estimated net out-migration (all ages) of 2,069; but for ages 20-24 in 1970, there is a substantial net in-migration and some in-migration for the age group 25 to 29. This type of opposite net flow is not unusual for a central city, and a substantial portion of the population of "Central County, USA" could be thus described. However, in this case a contributing factor is the presence of military population. It would be desirable to adjust for this factor and for colleges and institutions as well; there is also a small college in "Central County, USA." (See Section 2.33) As to the military base, there are no readily available data of any kind for dependents residing with a member of the military, so that the female population cannot be adjusted, short of a special count made at the military installation. Methods of adjusting for military, college,

[2] Although the estimated net migration 1960-70 is directly affected by the use of inappropriate survival rates, the population projected for 1980 using rates of migration based on these values is affected very little. See Section 3.234, formulas 3.6 and 3.7.

[3] Bowles, Beale, and Lee, op. cit.

[4] If NCSR's are used, residual net migration includes the net effect of the variation of local net census undercount from the pattern for the Nation.

and institutional population have been developed, but they involve a good deal of data input and computation.[5]

Column 6. Compute the rate of net migration by dividing the net migration (col. 5) by the expected population (col. 3). The initial population may also be used as the denominator, but the procedure recommended here is more commonly used.

3.2 Preliminary population projections. This section develops preliminary projections to 1980. Two tables are involved, table H-2, which carries out a computation for 1970-80 similar to that in table H-1 for 1960-70, and table H-3, which projects births as input to table H-2.

3.21 Projections by age, 1970-80, for cohorts 10 years of age and over in 1980 (table H-2). The preliminary projection of the population in this table is carried out in two sections. The first section projects the 1980 population 10 years of age and over. This provides the projection of the female population needed to calculate the number of births during the decade in table H-3. Once these births are obtained, table H-2 is completed by projecting the 1980 population under 10 years of age.

Column 1. The population on July 1, 1970 is obtained by extrapolation, age by age, of the April 1, 1960 and April 1, 1970 census counts given in table H-1 using the procedure described below. Population estimates and projections are usually prepared as of July 1 since they are often used as a denominator in computing rates representing a calendar year. Making a small adjustment at this step avoids converting all projected data to July 1 at a later step. The extrapolation is carried out by the formula:

$$P_x^{7/1/70} = (f_1 P_x^{4/1/70}) - (f_2 P_x^{4/1/60})$$

where P_x stands for the population of any age group x (not by cohort) on the dates indicated by the superscript, and f_1 and f_2 are State-specific factors given in table D-1. These factors, if applied to all counties of a State, will produce a population on

[5] Methods of adjusting for special populations are discussed in detail in Walter P. Hollmann and Isabel Hambright, "Population Projections as Affected by Special Populations: Problems and Solutions." Paper presented at the 1974 meeting of the Population Association of America, Seattle, Washington. See also Richard Irwin and Warren Kalbach, "A Technique for Handling Military, College, and Institutional Populations in Cohort Survival Computations for Small Areas." Paper presented at the 1964 meeting of the Population Association of America, San Francisco, California.

Table H-2. Preliminary Population Projection by Age for White Females, for "Central County, USA": July 1, 1970 to 1980

Line No.	Age of cohort: Age in 1970	Age of cohort: Age in 1980	Population July 1, 1970 and births 1970-80 (1)	Life table survival rates (projected) (2)	Expected population July 1, 1980 (3)=(1)x(2)	Net migration (4)= $\frac{(A6)x(3)}{100}$	Population July 1, 1980 (5)=(3)+(4)
1	All ages, total.......	All ages, total.....	[1]79,708	(X)	90,834	[2]-342	90,492
2	Born July 1, 1975-80..	0 to 4 years........	[3](8,591)	.9850	8,462	-1,717	6,745
3	Born July 1, 1970-75..	5 to 9 years........	[3](7,792)	.9820	7,652	-1,687	5,965
4	0 to 4 years..........	10 to 14 years......	6,956	.9960	6,928	-652	6,276
5	5 to 9 years..........	15 to 19 years......	7,717	.9966	7,691	-12	7,679
6	10 to 14 years........	20 to 24 years......	7,829	.9950	7,790	3,448	11,238
7	15 to 19 years........	25 to 29 years......	7,198	.9938	7,153	1,593	8,746
8	20 to 24 years........	30 to 34 years......	8,806	.9927	8,742	-902	7,840
9	25 to 29 years........	35 to 39 years......	6,256	.9901	6,194	-255	5,939
10	30 to 34 years........	40 to 44 years......	4,850	.9854	4,779	-228	4,551
11	35 to 39 years........	45 to 49 years......	4,716	.9771	4,608	-247	4,361
12	40 to 44 years........	50 to 54 years......	4,712	.9644	4,544	-74	4,470
13	45 to 49 years........	55 to 59 years......	4,865	.9464	4,604	-172	4,432
14	50 to 54 years........	60 to 64 years......	3,966	.9210	3,653	-7	3,646
15	55 to 59 years........	65 to 69 years......	3,307	.8851	2,927	-60	2,867
16	60 to 64 years........	70 to 74 years......	2,759	.8262	2,279	138	2,417
17	65 and over...........	75 and over.........	5,771	.4901	2,828	492	3,320

X Not applicable.
[1]Excluding births. Total including births is 96,091.
[2]Sum of individual values.
[3]Projected births, shown in parentheses to distinguish from estimated population.

July 1, 1970 consistent with the postcensal population estimate for the State on that date developed by the Bureau of the Census. This extrapolation procedure is not a postcensal estimate in the ordinary sense, but any error introduced is small. If an independent estimate of the July 1, 1970 population is available, the age detail can be adjusted pro rata so as to sum to the estimate.

The April 1, 1960 and 1970 population data are taken from table H-1 columns 1 and 4. Since table H-1 is arranged by cohort, in applying this formula to each age group one must take the 1960 population in column 1 from a line two spaces below the 1970 population in column 4. Thus on line 17 in column 1, the value for 1960 for the population 65 and over is shown, but in column 4 the last three values in lines 15, 16, and 17 must be summed to obtain the population aged 65 and over. The computation may be checked by computing an all ages total which will differ from the sum of the individual computations only slightly, due to individual rounding. This extrapolation produces data in table H-2 for line 1 and lines 4 to 17 in column 1. Lines 2 and 3 will be completed at a later step with preliminary projections of births for the decade 1970-80.

Column 2. Enter life table survival rates (LTSR's) projected for the 1970-80 decade (if LTSR's were used in table H-1). National rates will be found in table A-2. If national census survival rates were chosen in table H-1, they must also be used here. Projected NCSR's are given in Appendix B. If LTSR's specific to the locality or State are being used, they must be projected. It has not been uncommon in recent years to assume no change for the 1970-80 decade from the 1960-70 rates, although this introduces a small error.

Column 3. Compute the "expected" population in 1980 in the absence of net migration (except for the birth cohorts) by multiplying the 1970 population (col. 1) by the survival rates (col. 2).

Column 4. Compute the projected net migration for the period 1970-80 (except for the birth cohorts) by multiplying the 1960-70 rates (col. 6) of table H-1 by the population expected in 1980 (col. 3). The all ages rate in table H-1 is not used; the total projected net migration is the sum of the age detail.

In this illustration, net migration is projected as a rate, but some technicians prefer to use the absolute amount of net migration 1960-70. A compromise would be to first project net migration as a rate, but to control the calculation of net migrants for each cohort so as not to exceed the amount of net migration for the cohort of the same age in 1960-70 by more than a specified ratio, say 20 percent. In the interest of simplicity, this option is not shown. The net in-migration projected in the illustration for ages 20 to 24 and 25 to 29 is larger than that estimated for 1960-70, because the population in these age groups increased in size in the decade 1970-80. To the extent that the net in-migration in 1960-70 for these age groups was due to the dependents of military personnel, this increase is illogical, since it depends in fact on the projected size of the military bases in the area, which size is not a function of the population residing in the area. If basic data are available, some adjustment method of the type mentioned in Section 2.33 can be used. See Section 3.31 below for a further discussion of the distribution of projected net migration by age.

Column 5. Compute the preliminary projected population in 1980 aged 10 years and over by adding net migration (col. 4) to the expected population (col. 3).

At this point births must be projected in table H-3 for use in obtaining the population under 10 years of age in 1980.

3.22 Preliminary projections of births, 1970-80 (table H-3). This table illustrates the projection of births by race and sex for the periods July 1, 1970 to 1975 and July 1, 1975 to 1980 for use in projecting the population under 10 years of age in 1980. Columns 1 to 3 provide the births needed for the preliminary projection of the 1980 population; columns 4 and 5 give a similar calculation made after the postcensal estimate adjustment (table H-4) which revises the 1980 projected population (table H-6) and therefore the number of births during the projection period.

The birth projections utilize the general fertility rate (GFR) and relate the projection of the local GFR to projections for the Nation developed by the U.S. Bureau of the Census (shown in Appendix E). Age-specific fertility rates, rather than the relatively less precise GFR's, are often used in projections for

local areas, but the added accuracy obtained by the fineness of the detail may be overshadowed by distortions in the age detail of the projected female population, due to errors in projecting the age distribution of migrants.

For use in table H-2, only White female births are needed, but for illustrative purposes, the preliminary projections shown in table H-3 simultaneously carry out separate projections for All races, White and Black. The sum of the race detail does not necessarily equal the separate calculation of All races. The GFR's for the Nation needed at steps 5a to 5c are taken from Appendix E. Another basic input is the proportion of births which are male at step 9b. The illustrative projections use: All races, .5133; White, .5144; and Black, .5081. These are computed from final birth registration data for the Nation in 1970.

Table H-3. Preliminary and Revised Projections of Births by Race and Sex for "Central County, USA": July 1, 1970 to 1980

Procedural step	Preliminary projections			Revised projections	
	All races (1)	White (2)	Black[1] (3)	White (4)	Black[1] (5)
1. Births					
(a) 1969	5,570	3,625	1,945		
(b) 1970	5,628	3,615	2,013		
(c) 1971	5,563	3,545	2,018		
2. Average births 1969-71 [(2)=(1a+1b+1c)÷3]	5,587	3,595	1,992		
3. Female population aged 15-44 years July 1, 1970	53,123	36,539	16,584		
4. County general fertility rate 1970 [(4)=(2)÷(3)]	.1052	.0984	.1201	NO REVISION	NO REVISION
5. U.S. general fertility rate (Series II)[2]					
(a) 1970	.0875	.0835	.1138		
(b) July 1, 1970-75	.0739	.0700	.0991		
(c) July 1, 1975-80	.0722	.0688	.0923		
6. Fertility ratio, 1970 [(6)=(4)÷(5a)]	1.2023	1.1784	1.0554		
7. County general fertility rate					
(a) July 1, 1970-75 [(7a)=(6)x(5b)]	.0888	.0825	.1046		
(b) July 1, 1975-80 [(7b)=(6)x(5c)]	.0868	.0811	.0974		
8. Female population aged 15-44 years					
(a) July 1, 1980	63,194	45,993	17,201	46,934	17,788
(b) Jan. 1, 1973 [.75(3)+.25(8a)]	55,641	38,902	16,738	39,138	16,885
(c) Jan. 1, 1978 [.25(3)+.75(8a)]	60,676	43,630	17,047	44,335	17,487
9. Projection of births July 1, 1975-80					
(a) Total births [(9a)=(7b)x(8c)x5.0]	26,333	17,692	8,302	17,978	8,516
(b) Proportion male of total births	.5133	.5144	.5081	.5144	.5081
(c) Male births [(9c)=(9a)x(9b)]	13,517	9,101	4,218	9,248	4,327
(d) Female births [(9d)=(9a)-(9c)]	12,816	8,591	4,084	8,730	4,189
10. Projections of births July 1, 1970-75					
(a) Total births [(10a)=(7a)x(8b)x5.0]	24,705	16,047	8,754	16,144	8,831
(b) Male births [(10b)=(10a)x(9b)]	12,681	8,255	4,448	8,305	4,487
(c) Female births [(10c)=(10a)-(10b)]	12,024	7,792	4,306	7,839	4,344

[1]Includes in addition to the Black population, all races other than White.

[2]Consistent with the Series II projections of fertility in "Projections of the Population of the United States: 1975-2050." U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 601, October, 1975. The general fertility rate is presented here per woman, rather than per 1,000 women, as is the custom for analytical tables.

The procedural steps in the calculation of the preliminary projections (cols. 1-3) are as follows:

Step 1. Births, 1969-71. Enter the number of registered births for the years indicated at steps 1a to 1c, in columns 1-3.

Step 2. Calculate the average number of births per year for the 3-year period as shown and enter here.

Step 3. Enter the female population aged 15-44 years on July 1, 1970 after summing the data in table H-2, column 1, (lines 7-12) for the appropriate age groups.

Step 4. The general fertility rate (GFR) for the county (or other local area) in calendar year 1970 is calculated as shown and entered here as a rate per woman. This rate is customarily shown per 1,000 women, as in Appendix E.

Step 5. The GFR for the Nation[6] in calendar year 1970 and projected for the periods July 1, 1970 to 1975, and July 1, 1975 to 1980 from table E-1 is entered at the appropriate steps, 5a to 5c. (Entered as a rate per woman, not per 1,000 women.)

Step 6. Calculate the ratio of the local GFR in 1970 to that of the Nation as shown, and enter here.

Step 7. This ratio is assumed to continue to 1980, and projected GFR's for the county are obtained by multiplying this ratio by the GFR projected for the Nation for the two 5-year periods indicated, entering the data at steps 7a and 7b. If desired, it can be assumed that the local GFR will converge to the national rate at some selected future date, and the ratio in step 6 can be adjusted by making it approach 1.

Step 8. Enter the projected female population aged 15-44 years on July 1, 1980 at step 8a after summing the data in table H-2, column 5 for the appropriate age groups (lines 5-10). The populations for the midpoints of the two 5-year time periods involved (January 1, 1973 and January 1, 1978) are obtained by straight-line interpolation between the July 1, 1970 and 1980 data, as indicated, and entered at steps 8b and 8c.

Step 9. Compute the births for the 1975-80 period (who will become the population 0-4 years in 1980) by multiplying the appropriate GFR (7b) by the population at the midpoint of the period (8c). Since the GFR is for a 1-year period, the result must be multiplied by 5 to produce total births which in turn are multiplied by the proportion of births which are male (9b, taken from national data for 1970) to obtain male births, entered at step 9c. Female births for step 9d equal total births minus male births.

Step 10. A similar computation is made for births from July 1, 1970 to 1975, as shown. The projections indicate 8,591 White female births for July 1, 1975 to 1980; and 7,792 for July 1, 1970 to 1975.

Effect of Alternative Fertility Assumptions. The procedure for projecting births described above makes the assumption that the general fertility rate for "Central County, USA" will maintain a constant ratio to the rate projected for the Nation under Series II of the most recent national population projections prepared by the U.S. Bureau of the Census.[7] In the national projections the regular Series I, II, and III differ only with respect to the fertility assumptions. Series II, the middle Series, assumes an average of 2.1 children per woman at completion of childbearing, which is approximately the rate at which population change would be zero (in the absence of immigration) if it continued long enough. Series I assumes 2.7, and Series III, 1.7 children per woman.

To illustrate the impact of these alternative series on the actual number of births projected, calculations were carried out consistent with the Series I and Series III assumptions for the period 1975 to 1980. The projections of births were 10,021 and 7,436, respectively. These are 17 percent higher and 13 percent lower than the Series II projection of 8,591.

The computation now returns to table H-2 to enter the Series II birth projections in column 1, lines 2 and 3, to complete the projection of the population under 10 years of age in 1980.

3.23 Projections by age, 1970-80, for cohorts under 10 years of age in 1980 (table H-2 cont.).

Column 1. Enter the 8,591 White female births projected for the period July 1, 1975 to 1980 on line 2 of this column, and the 7,792 births for the period July 1, 1970 to 1975 on line 3.

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[6]The rates used here are consistent with Series II of the national population projections of the U.S. Bureau of the Census. See further discussion under Effect of Alternate Fertility Assumptions in Section 3.22 regarding alternative series.

[7]U.S. Bureau of the Census, **Current Population Reports**, Series P-25, No. 601, op. cit.

Column 2. The survival rates have already been entered.

Column 3. Compute the "expected" population under 10 years of age in 1980 by multiplying column 1 by column 2.

Column 4. Compute the net migrants by multiplying the 1960-70 rates in table H-1, column 6, by the expected population (col. 3).

Column 5. The preliminary population projection for the birth cohorts is the sum of the "expected" population (col. 3) and net migrants (col. 4).

3.3 Adjustment of preliminary projection of net migration, 1970-80, for postcensal estimate (table H-4). This table generates the revised net migration needed as a first step toward obtaining a revised population projection on July 1, 1980, adjusted to take account of a postcensal estimate, in this case for July 1, 1974. The general procedure is to begin with the estimated net migration for the period 1970-74 and add to it a projection of migration from 1974 to 1980 obtained by assigning weights to (1) the 1970-80 average annual rate of projected net migration, and (2) the 1970-74 average annual rate of net migration indicated by the 1974 postcensal estimate. In this example, equal weight is given to each trend, following the notion that although the 1970-80 rate is a reflection of the ten-year intercensal period 1960-70, as compared to only a four-year period for the postcensal estimate, the more recent experience should be given relatively more weight. A simple resolution of these two opposing factors is to assign equal weight to each trend.

However, the analyst developing the basic assumptions is free to assign weight as seems most reasonable, or simply insert a different projected net migration for the period 1974-80 as indicated by externally developed projections. These options are discussed in the material which follows.

Presentation of basic data

Step 1. Preliminary projected net migration. Here the all ages migration 1970 to 1980 of -342, calculated for White females at line 1, column 4 of table H-2 is entered at step 1b, along with results of similar calculations (not shown) for the three remaining race-sex groups at the appropriate steps. Enter the sum of the data at step 1e as the all classes total.

Step 2. Enter the estimated population for the most recent postcensal date, in this case July 1, 1974. This estimate was prepared under the Federal-State Cooperative Program and published in **Current Population Reports**, Series P-26, U.S. Bureau of the Census. (See Exhibit 4-A for a complete reference.) Since race detail is not published, this example uses only data for all classes.

Step 3. Enter the estimated net migration from April 1, 1970 to July 1, 1974 from the source just cited. Since the base date for the preliminary projections is July 1, 1970, at step 3a a straight-line interpolation takes 16/17, or .941176 of the original total, to adjust for the 3-month difference.

Step 4. Calculate the total population on July 1, 1970 needed as a base for computing migration rates from the above data by entering at steps 4a to 4d the values by race and sex obtained in column 1, table H-2 for White females, and similar computations not shown for other race-sex groups. Calculate the all classes population by summing these data and enter it in 4e.

Adjustment of net migration (All classes)

Step 5. Average annual rate of projected net migration, 1970-80. This is obtained by taking 1/10 of the rate of net migration for the 10-year period (the preliminary net migration total divided by the total population on July 1, 1970). A refinement would be to calculate the geometric rate instead of the arithmetic average calculated here, but for low rates of net migration, there is little difference. In the computer, or on a modern statistical calculator, the geometric rate is easily calculated, and in Section 5 of this appendix, this geometric calculation is explained while demonstrating the steps for adjusting projections for individual counties to agree with an area total. (Although most of the computations in this illustration are carried out to only four decimals, factors to be used in subsequent adjustments are carried out to six decimals, as in this instance.)

Step 6. Average annual rate of estimated net migration, 1970-74. The computation is exactly as described above, except that the 1970-74 rate is divided by 4 to obtain the annual average.

Step 7. Projected average annual rate of net migration, 1974-80. The procedure recommended here is to average the 10-year and the 4-year rates, to obtain a projected value to carry forward from

Table H-4. Revision of Preliminary Projection of Net Migration by Race and Sex for Postcensal Estimate, for "Central County, USA": July 1, 1970 to 1980

(All data are for population of all ages. See text for data sources and method of computation)

Procedural step	Data
PRESENTATION OF BASIC DATA	
1. Preliminary net migration, July 1, 1970 to July 1, 1980	
(a) White males	4,994
(b) White females	-342
(c) Black males[1]	-7,794
(d) Black females[1]	-7,800
(e) All classes, total $(1e)=\Sigma_a^d(1)$	-10,942
2. Estimated population (all classes): July 1, 1974	259,900
3. Estimated net migration (all classes): April 1, 1970 to July 1, 1974	-1,300
(a) Adjustment to period July 1, 1970 to July 1, 1974 (3a)=.941176x(3)	-1,224
4. Population, July 1, 1970	
(a) White males	89,590
(b) White females	79,708
(c) Black males[1]	37,872
(d) Black females[1]	41,426
(e) All classes, total	248,596
ADJUSTMENT OF NET MIGRATION (ALL CLASSES)[2]	
5. Average annual rate of projected net migration: 1970-80 (5)=[(1e)÷(4e)]÷10.0	-.004402
6. Average annual rate of estimated net migration: 1970-74 (6)=[(3a)÷(4e)]÷4.0	-.001231
7. Projected average annual rate of net migration: 1974-80 $(7)=\frac{1}{2}(5)+\frac{1}{2}(6)$ [Equal weight]	-.002817
8. Projected rate of net migration: 1974-80 (8)=6.0 x (7)	-.016902
9. Projected net migration: 1974-80 (9)=(8)x(2)	-4,393
10. Revised projection of net migration (all classes): 1970-80 (10)=(9)+(3a)	-5,617
11. Amount and direction of adjustment to preliminary net migration (11)=(10)-(1e)	+5,325
ADJUSTMENT OF NET MIGRATION (BY RACE AND SEX): 1970-80	
12. Adjustment factor (12)=(11)÷(4e)	.021420
13. Amount and direction of adjustment to net migration by race and sex $(13)=(12)\times(4)_a^d$	
(a) White males	1,919
(b) White females	1,707
(c) Black males[1]	811
(d) Black females[1]	887
(e) All classes, total $(13e)=\Sigma_a^d(13)$	5,324
14. Revised net migration by race and sex $(14)=(1)_a^d+(13)_a^d$	
(a) White males	6,913
(b) White females	1,365
(c) Black males[1]	-6,983
(d) Black females[1]	-6,913
(e) All classes, total $(14e)=\Sigma_a^d(14)$	-5,618

[1]Includes, in addition to the Black population, all races other than White.
[2]All dates for steps 5 to 14 are July 1 of the year indicated.

1974. However, a different weighting scheme can be used, depending on the judgment of the analyst. If it appears probable that the 1970-74 trend will continue, more weight can be given it. If an externally prepared projection of net migration for 1974-80 has been developed, this step and the next can be omitted, and the projected net migration entered at step 9.

Step 8. Projected rate of net migration, 1974-80. This is obtained by simply multiplying the annual rate in the previous step by 6. (If the computation at steps 5 and 6 is geometric, the calculation here would be exponential. See Section 5 below for this application.)

Step 9. Projected net migration, 1974-80. This is the product of the 6-year rate in step 8 multiplied by the 1974 population.

Step 10. Revised projection of net migration, 1970-80. Adding the 1974-80 value in step 9 to that for 1970-74 in step 3a provides the revised net migration for the decade. In effect this procedure bases the 1980 projection on the postcensal estimate for 1974, but operationally the 1980 population is obtained by revising the 1970-80 preliminary projection to take the 1974 estimate into account.

Step 11. Amount and direction of adjustment to preliminary net migration. The computation indicated here calculates the adjustment to be applied to the preliminary net migration (all classes) needed to produce the desired net migration in step 10. The remaining steps distribute this all classes total by race and sex.

Adjustment of preliminary net migration
(By race and sex): 1970-80

The amount of the adjustment indicated in step 11 must be distributed by race and sex. In this example the distribution is based on population. It is also possible to base the adjustment on the preliminary net migration for each race-sex group. If migration is used, it may be that contrasting signs will be encountered, as in this example, and a "plus-minus" adjustment can be employed. This technique is demonstrated further on (table H-5) in revising

Table H-5. Adjustment of Preliminary Net Migration by Age to Revised Total Net Migration, for White Females, "Central County, USA": July 1, 1970 to 1980

Line No.	Age of cohort		Preliminary net migration (1)	Amount of adjustment (2)=(1)x(f)[1]	Revised net migration (3)=(1)+(2)
	Age in 1970	Age in 1980			
1	All ages, total.........	All ages, total.....	-342	1,707	1,365
2	Born July 1, 1975-80....	0 to 4 years........	-1,717	251	-1,466
3	Born July 1, 1970-75....	5 to 9 years........	-1,687	246	-1,441
4	0 to 4 years...........	10 to 14 years......	-652	95	-557
5	5 to 9 years...........	15 to 19 years......	-12	2	-10
6	10 to 14 years..........	20 to 24 years......	3,448	504	3,952
7	15 to 19 years..........	25 to 29 years......	1,593	233	1,826
8	20 to 24 years..........	30 to 34 years......	-902	132	-770
9	25 to 29 years..........	35 to 39 years......	-255	37	-218
10	30 to 34 years..........	40 to 44 years......	-228	33	-195
11	35 to 39 years..........	45 to 49 years......	-247	36	-211
12	40 to 44 years..........	50 to 54 years......	-74	11	-63
13	45 to 49 years..........	55 to 59 years......	-172	25	-147
14	50 to 54 years..........	60 to 64 years......	-7	1	-6
15	55 to 59 years..........	65 to 69 years......	-60	9	-51
16	60 to 64 years..........	70 to 74 years......	138	20	158
17	65 and over.............	75 and over.........	492	72	564

[1] f=.146097. This adjustment factor is obtained by dividing the amount of adjustment (+1,707) by the absolute sum of column 1 (11,684). The amount of adjustment for each age group is given the sign of the all ages adjustment.

the age distribution of net migrants. For the distribution shown here by race and sex, population is the recommended basis. The main problem is the division by race, and it would be very desirable to develop the postcensal estimate separately for the White and Black populations, permitting the adjustment to the postcensal estimate in this table to be carried out by race.

Step 12. Calculate this adjustment factor by dividing the amount of the adjustment (step 11) by the total population in 1970 (step 4e).

Step 13. Calculate the amount and direction of adjustment to net migration by race and sex by multiplying the factor in step 12 by the 1970 population shown at steps 4a to 4d. This obtains the adjustment to each race-sex group, entered at steps 13a to 13d. The sum of a to d is entered at step 13e and should agree with step 11, except for individual rounding.

Step 14. Calculate revised net migration by race and sex by adding the adjustment (steps 13a to 13d) to preliminary net migration (steps 1a to 1d). Enter the sum of 14a through d at 14e. This should agree with step 10, except for individual rounding. The revised net migration for White females of 1,365 is now entered in table H-5, where the revised distribution by age is calculated.

3.31 Adjustment of preliminary net migration by age to revised total net migration, 1970-80 (table H-5). This table demonstrates a method of adjusting the preliminary distribution of net migration by age to a new total, in this case the result of the adjustment to the postcensal estimate (table H-4). If all age groups have the same sign, the distribution can be simply adjusted pro rata to agree with the desired total. If, however, the original distribution has both positive and negative values, as is the case here, the plus-minus technique is recommended, although there are limitations to its use.[8] In the example shown here the adjustment is of moderate size, but in other situations may be very large and the adjustment procedure may seriously distort the original distribution. As an alternative to the plus-minus technique, it is possible to base the adjustment on population; and there is a "translation" technique which can be used.[9] If, however, the adjustment is large enough in relation to the original values, none of these procedures is satisfactory, and it may be necessary to assign an age distribution in some other way. One alternative is by reference to the "typology" of such distributions.[10] Since the adjustment in the illustration below is moderate, the plus-minus technique is satisfactory.

Column 1. Preliminary net migration. This column is the preliminary 1970-80 projection by age calculated in column 4, table H-2.

Column 2. Amount of adjustment. The all ages total in this column is the amount of adjustment shown at step 13b of table H-4. The plus-minus technique shown here distributes this adjustment by age according to the size of each item in the original distribution, without regard to sign. The adjustment factor f is obtained by dividing the all ages adjustment (+1707) by the absolute sum of the original distribution in column 1 (11,684). This factor, multiplied by the original distribution (disregarding sign), gives the amount of adjustment for each age group. The sum of the individual items will agree with the all ages total, except for individual rounding.

Column 3. Revised net migration. This is the sum of the preliminary projections (col. 1) and the amount of adjustment (col. 2). These revised figures are subsequently entered in column 4, table H-6. The all ages total of column 3 should equal step 14b of table H-4.

3.32 Comparison of preliminary and revised net migration. For "Central County, USA", the adjustment to preliminary net migration was minor, and the revised distribution by age is little different from the preliminary distribution (figure 3). However, a much larger adjustment was required for "Exurban County, USA" in a similar computation (figure 4). In this case, the shape of the distribution is more fundamentally altered by the revision.

Moving to a comparison of the migration pattern between the two counties, the striking difference between the distributions of net migration by age is not unusual for counties within a metropolitan area.[11] "Central County, USA" attracts young adults but loses migrants under 15 and over 30 years of age to the suburbs. The distribution for "Exurban County, USA" is almost a mirror image of the

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[8] See Shryock, Siegel, and Associates, op. cit., pp. 705-6, 1971.

[9] Ibid., p. 706.

[10] See Pittenger, op. cit.

[11] Although figure 4 is for males, the distribution for females in "Exurban County, USA," which would be directly comparable with figure 3, is similar in general shape to that for males.

Figure 3. Preliminary and Revised Projections of Net Migration for White Females, "Central County, USA": July 1, 1970 to July 1, 1980

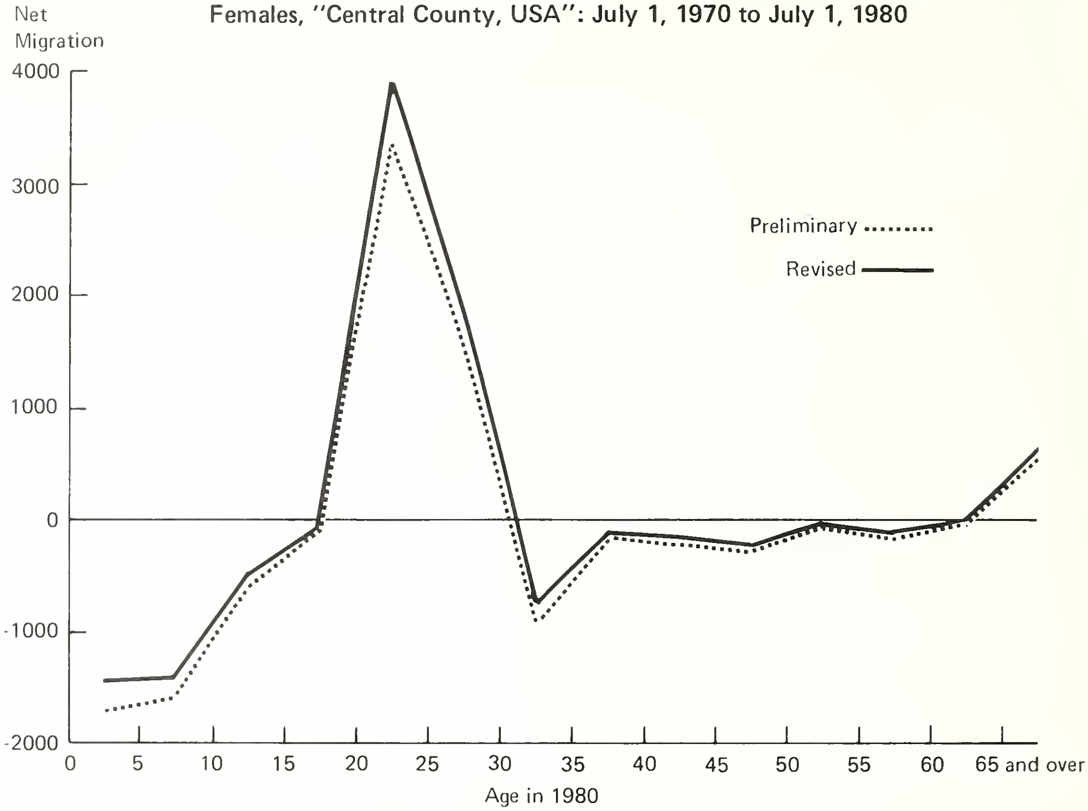
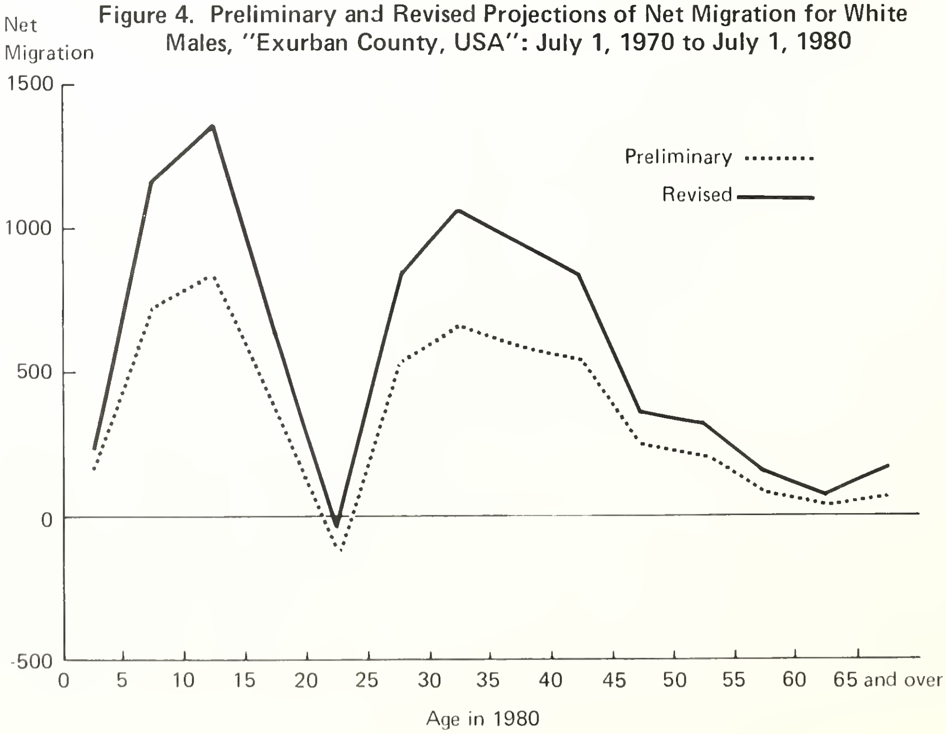


Figure 4. Preliminary and Revised Projections of Net Migration for White Males, "Exurban County, USA": July 1, 1970 to July 1, 1980



central county. This pattern of migration for central cities and surrounding suburbs is encountered in many U.S. metropolitan areas. Of course, these county net migration patterns reflect migration to and from areas outside of the metropolitan area, in addition to those moving within the area.

3.4 Revised population projections. The preliminary projections in table H-2 may now be revised using the migration data developed in table H-5. Table H-6 provides the basic framework for this revision, but table H-3 must be reentered to compute revised projections of births.

3.41 Projections by age, 1970-80, for cohorts 10 years of age and over in 1980 (table H-6). This table produces the final population projection for 1980 by age, including all adjustments if only a single county is involved. (The additional adjustments required if the projections are prepared for a group of counties are shown in Section 5 below.) The format of the table is identical with the preliminary projection (table H-2), and the data in columns 1 to 3, except for the birth cohorts on lines 2 and 3, are identical. The revised net migration from table H-5 results in a revised 1980 projection, which in turn requires a revised projection of births, shown in columns 4 and 5 of table H-3.

Columns 1 and 2. There is no change in lines 4 to 17 from the preliminary projection in table H-2, and the data do not need to be entered.

Column 3. Enter the expected population on lines 4 to 17, taken from table H-2.

Column 4. Enter revised net migration from table H-5, column 3. Since no further revision is made in these data, the complete column is entered, including the birth cohorts on lines 2 and 3.

Column 5. Calculate the final projected population in 1980 aged 10 years and over by adding columns 3 and 4. The female population aged 15 to 44 years is now used to revise the projection of births in table H-3.

3.42 Revised projections of births, 1970-80 (table H-3 continued).

Step 8. Enter the revised female population at step 8a of column 4. Steps 1 to 7 need not be entered, since the revision does not affect these data. At steps 8b and 8c, the female population for the midpoints of the two 5-year periods is obtained by interpolation, using the 1970 data (col. 2) and the revised 1980 data (col. 4). The calculation for the Black population is included, as it is needed at a later stage.

Step 9. Calculate total births for the period July 1, 1975 to 1980 as indicated and enter at step 9a. Using the proportion of births which are male on line 9b, calculate births by sex and enter at steps 9c and 9d. These revised births will be used to obtain the revised population aged 0 to 4 years in 1980.

Table H-6. Revised Population by Age for White Females, "Central County, USA": July 1, 1970 to 1980

Line No.	Age of cohort: Age in 1970	Age of cohort: Age in 1980	Population July 1, 1970 and births 1970-80 (1)	Life table survival rates (projected) (2)	Expected population July 1, 1980 (3)=(1)x(2)	Revised net migration (from col.(3), table H-5) (4)	Revised population July 1, 1980 (5)=(3)+(4)
1	All ages, total.......	All ages, total.....	[1]79,708	(X)	91,017	[2]1,365	92,382
2	Born July 1, 1975-80..	0 to 4 years........	[3]8,730	.9850	8,599	-1,466	7,133
3	Born July 1, 1970-75..	5 to 9 years........	[3]7,839	.9820	7,698	-1,441	6,257
4	0 to 4 years..........	10 to 14 years......	Not required--same as table B		6,928	-557	6,371
5	5 to 9 years..........	15 to 19 years......			7,691	-10	7,681
6	10 to 14 years........	20 to 24 years......			7,790	3,952	11,742
7	15 to 19 years........	25 to 29 years......			7,153	1,826	8,979
8	20 to 24 years........	30 to 34 years......			8,742	-770	7,972
9	25 to 29 years........	35 to 39 years......			6,194	-218	5,976
10	30 to 34 years........	40 to 44 years......			4,779	-195	4,584
11	35 to 39 years........	45 to 49 years......			4,608	-211	4,397
12	40 to 44 years........	50 to 54 years......			4,544	-63	4,481
13	45 to 49 years........	55 to 59 years......			4,604	-147	4,457
14	50 to 54 years........	60 to 64 years......			3,653	-6	3,647
15	55 to 59 years........	65 to 69 years......			2,927	-51	2,876
16	60 to 64 years........	70 to 74 years......			2,279	158	2,437
17	65 and over..........	75 and over.........			2,828	564	3,392

X Not applicable.
[1]Excluding births. Total including births is 96,277.
[2]Sum of individual values.
[3]Projected births.

Step 10. Births by sex for the period July 1, 1970 to 1975 are similarly calculated, and will become the population aged 5-9 years in 1980.

3.43 Projections by age, 1970-80, for cohorts under 10 years of age in 1980 (table H-6 continued).

Column 1. Enter on lines 2 and 3 the revised projections of births from table H-3.

Column 2. Enter the life table survival rates already used in table H-2 on lines 2 and 3.

Column 3. Calculate the expected population by multiplying the births (col. 1) by the survival rate (col. 2).

Column 4. Revised net migration for the birth cohorts should already have been entered according to previous instructions. In the interest of simplicity, no adjustment is made here to net migration for the birth cohorts, even though the change in number of births implies a change in net migration. Implicitly, we allow the rate of net migration to be adjusted.

Column 5. Calculate the revised population in 1980 for the two birth cohorts on lines 2 and 3 by adding revised net migration (col. 4) to the expected population (col. 3). This completes the revised projection for 1980, and the sum of the column is the total figure for White females.

3.44 Age and sex of the population, 1970-80 (figure 5). After the computations for each of the four race-sex groups are completed through table H-6, the projected population by age can be presented graphically. Figure 5 shows the population (all races) by age and sex in 1970 and 1980. For 1980 there is a large increase in the population aged 65 and over, and in the range 20 to 39 years.

The population growth in the young adult ages is partly due to the large increase nationally in the number of births between 1940 and 1960, but the presence of a military base and a small college in "Central County, USA" accentuate this increase, especially for the age group 20-24, as was mentioned above (p. 59). This results from the assumption that the rate of net migration for the period 1960-70 will continue in the succeeding decade. In this special case the assumption is illogical, since the in-migration of military personnel is not necessarily related to the size of the population residing in the local area. This problem can be alleviated by applying a limiting factor to the migration projection for each cohort, but a complete adjustment requires special techniques (see Section 2.33). No adjustment has been made along these lines in the illustrative projections in order to demonstrate the degree to which these factors can alter the age distribution.

3.5 Projections summary. Data for the year 1975 are prepared in tables H-7 and H-8, since it is useful to have projections for each 5-year time period. Table H-8 also summarizes the population by age, and table H-9 gives a summary of the components of change.

3.51 Interpolation for projected population, 1975 (table H-7). This table provides for a projected population (all ages) for each race-sex group for 1975, by means of a modified interpolation procedure which takes account of the 1970 estimated and the 1980 projected population by race and sex, and the 1974 estimated total population.

Steps 1 and 2. Enter the 1970 and 1980 populations by race and sex from the sources indicated.

Step 3. A preliminary interpolation for each race-sex group for 1975 is obtained by averaging the 1970 and 1980 populations as indicated.

Step 4. Enter the postcensal estimate from the indicated source (not available by race and sex).

Step 5. The final 1975 projection (all classes) is obtained by linear interpolation between the 1974 estimate and the 1980 projection. As a refinement, the interpolation could assume a constant annual rate of change. For small rates of population change there is little difference between the two assumptions.

Step 6. The race-sex values at step 3 are adjusted pro-rata to sum to the all classes total at step 5.

3.52 Summary of population by age, 1970, 1975 and 1980 (table H-8). This table produces the 1975 population projections by age, using a cohort factor derived from the national population projections to adjust the data obtained by interpolation. The columns of the table are arranged to facilitate presentation of the final data, not in the order of entry and computation. The data in columns 1, 3, and 5 are posted from other tables, and columns 2 and 4 are the preliminary and final interpolation values derived for the year 1975.

Columns 3 and 5. Enter the populations by age for 1970 and 1980, as previously developed, from the sources cited in the table.

Figure 5. Age and Sex of the Population of "Central County, USA": July 1, 1970 and July 1, 1980

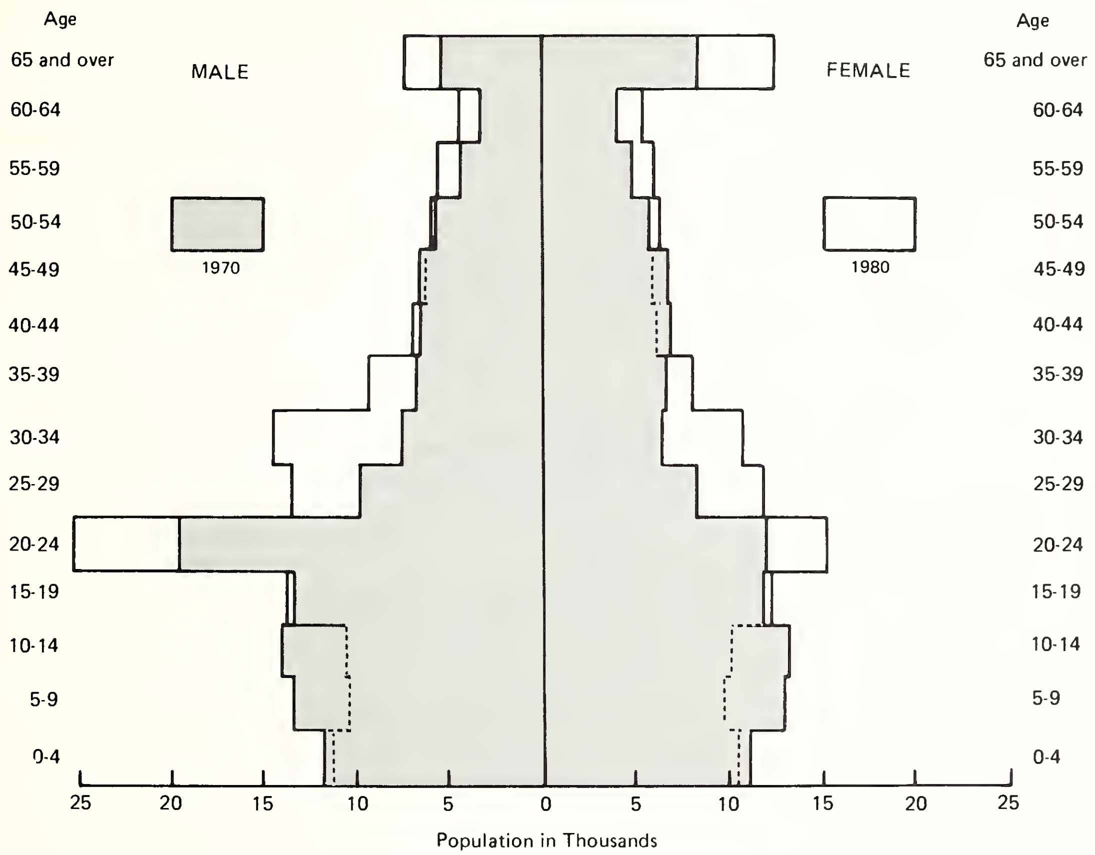


Table H-7. Interpolation for Projected Population by Race and Sex, "Central County, USA": July 1, 1975

Procedural step (Year as of July 1)	All classes[1]	Race and sex			
		White		Black[2]	
		Male	Female	Male	Female
1. Estimated population, 1970	248,596	89,590	79,708	37,872	41,426
2. Projected population, 1980	275,284	107,509	92,382	35,797	39,596
3. Prelim. interpolated population 1975 $(3)=\frac{1}{2}(1)+\frac{1}{2}(2)$	261,940	98,550	86,045	36,834	40,511
4. Estimated population, 1974	259,900	(X)	(X)	(X)	(X)
5. Interpolated population (all ages), 1975 $(5)=5/6\ (4)+1/6\ (2)$	262,464	(X)	(X)	(X)	(X)
6. Population by race and sex, 1975 $(6)=(3)\times\Sigma(5)\div\Sigma(3)$	262,464	98,747	86,217	36,908	40,592

X Not applicable.
[1]Sum of race-sex values.
[2]Includes, in addition to Black, all races other than White.

Sources: (for data on white females; other race-sex computations not illustrated.)
Step 1. Table H-2, column 1, line 1.
Step 2. Table H-6, column 5, line 1.
Step 4. Table H-4, step 2.

Table H-8. Summary of Population by Age for White Females, "Central County, USA", with Interpolation for 1975 Population: July 1, 1970, 1975 and 1980

Age	Cohort adjustment factor (1)	Population (July 1)			
		Preliminary 1975[1] (2)	1970 (3)	Final 1975 $(4)=(2)\times(f)^2$	1980 (5)
All ages total............	(X)	[3]86,161	79,708	[3]86,217	92,382
0 to 4 years..............	.9219	6,494	6,956	6,498	7,133
5 to 9 years..............	.9666	6,754	7,717	6,758	6,257
10 to 14 years............	1.0601	7,527	7,829	7,532	6,371
15 to 19 years............	1.0567	7,861	7,198	7,866	7,681
20 to 24 years............	1.0112	10,389	8,806	10,396	11,742
25 to 29 years............	1.0489	7,990	6,256	7,995	8,979
30 to 34 years............	.9801	6,283	4,850	6,287	7,972
35 to 39 years............	.9289	4,966	4,716	4,969	5,976
40 to 44 years............	.9395	4,367	4,712	4,370	4,584
45 to 49 years............	1.0199	4,723	4,865	4,726	4,397
50 to 54 years............	1.0600	4,477	3,966	4,480	4,481
55 to 59 years............	.9929	3,854	3,307	3,857	4,457
60 to 64 years............	1.0028	3,212	2,759	3,214	3,647
65 years and over.........	1.0036	7,264	5,771	7,269	8,705

X Not applicable.
[1]Computed from: $(2) = (1) \times [\frac{1}{2}(3) + \frac{1}{2}(5)]$
[2]Adjustment factor, (f = 1.000650), is the quotient of the final all ages total (table H-7, step 6) divided by the all ages sum of column 2.
[3]Sum of age detail.

Sources: Column 1. Table F-1, column 4.
Column 3. Table H-2, column 1.
Column 5. Table H-6, column 5.

Column 1. Enter the national cohort-size adjustment factors in this column, from the data provided in table F-1. The use of these factors is advisable because the interpolation procedure followed in table H-8 is by age, not by cohort. The interpolation by age obtains a value for each 5-year cohort in 1975 by interpolating, in effect, between data for the two adjacent cohorts (the next younger and next older). If the size of cohorts in the U.S. population followed a smooth progression from group to group, there would be no problem. However, the fluctuations in the number of births during the past 40 years have produced variations in the progression from age to age in the size of cohorts, and the use of the factor adjusts for this variation.

Column 2. A preliminary interpolation to 1975 is carried out in this calculation by averaging the 1970 and 1980 populations and multiplying by the cohort-size adjustment factor as indicated in footnote 1. After carrying out the computations by age for each age group, the column is summed to obtain the all ages total. Note that the value for the youngest age group could be obtained by adjusting projected births during the first 5 years of the decade for mortality and migration. This procedure suggests a higher value of about 6,700 for this group.

Column 4. The final distribution for 1975 is obtained by adjusting column 2 pro rata to agree with the all ages figure obtained at step 6 of table H-7. The computation is shown in footnote 2.

The arrangement of columns 3, 4, and 5 provides a summary of the population projections by age. For intermediate years within the 5-year periods, compute projections with straight-line interpolation age by age, adjusting the age detail pro rata to a control total, if available.

3.53 Components of change by race and sex, 1960-80 (table H-9). This table displays the components of change developed by the projections procedure. The population data for April 1, 1960 and 1970 are from table H-1, and for July 1, 1970 and 1980, from tables H-2 and H-6, respectively. Births are calculated by adding lines 2 and 3 of column 1 from table H-1 (for 1960-70) and table H-6 (for 1970-80).

From the same tables deaths are calculated as the difference between the total population in column 1, (including births during the decade, shown in footnote 1) and the expected population, all ages, in column 3. Net migration is shown directly, being the all ages total in table H-1, column 5 (1960-70) and table H-6, column 4 (1970-80).

The summaries in tables H-8 and H-9 complete the step-by-step illustration of the population projections. A method of relating the projections to the growth of the labor force for the purpose of evaluating the population projections is shown in Appendix G. The extension of the projections to a date 10 years beyond the postcensal estimate, in this case 1984, is described in the next section. Section 5 then describes the procedure for using a control total for a multi-county area to revise the preliminary county projections of net migration.

Table H-9. Components of Change by Race and Sex for "Central County, USA": 1960 to 1980

(See text for sources of data)

Components of change and date	All classes	White		Black[1]	
		Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)
Population, April 1, 1960	216,382	70,775	66,674	37,543	41,390
Net change, 1960-70	31,268	18,299	12,666	296	7
Births	62,481	19,787	19,044	11,967	11,683
Deaths	16,944	5,371	4,309	3,737	3,527
Net migration	-14,269	3,883	-2,069	-7,934	-8,149
Population, April 1, 1970	247,650	89,074	79,340	37,839	41,397
Population, July 1, 1970	248,596	89,590	79,708	37,872	41,426
Net change, 1970-80	26,688	17,919	12,674	-2,075	-1,830
Births	51,469	17,553	16,569	8,814	8,533
Deaths	19,167	6,549	5,260	3,908	3,450
Net migration	-5,614	6,915	1,365	-6,981	-6,913
Population, July 1, 1980	275,284	107,509	92,382	35,797	39,596

[1]Includes, in addition to the Black population, all races other than White.

4. Optional Extension of Projections

In order to extend the projections 10 years beyond the estimate date of 1974, further computations are required. This section will not describe the procedures step by step. However, the required techniques already have been demonstrated in detail, and with general instructions, the technician should be able to carry out the extension without difficulty.

Since the projection model is for a 10-year period, the simplest way to obtain the required data is to carry the 1980 projections forward 10 more years to 1990, and interpolate to obtain figures for 1984. For this purpose, tables of survival rates for the period 1980-90 have been included as table A-3 (Life Table Survival Rates) and table B-3 (National Census Survival Rates). The projected general fertility rates needed for the Nation are shown in table E-1. Given these data, the 1980-90 projections are very similar to the preliminary 1970-80 projections in table H-2.

A decision must be made, however, about the migration rates to be used for the projections. The procedure involving the least computation is to assume that the original migration rates for 1960-70 will hold for 1970-80. In some cases there may be justification for this assumption. If, however, the 1974 postcensal estimate differs sharply from the preliminary projections in table H-2, such an assumption may be untenable.

An alternative procedure is to assume that the 1980-90 period will have the same migration rates as did the revised 1970-80 projections in table H-6. This procedure gives some weight to the 1974 estimate in determining the migration trend for 1980-90.

In order to execute this alternative procedure, it is necessary to compute rates for the 1970-80 revised net migration from data in table H-6. This is done by dividing the revised net migration (col. 4) by the expected population (col. 3). These revised migration rates would be multiplied by the expected population for 1990 in column 3 of a new version of table H-2 covering the period 1980-90. Births would be obtained by a new table H-3, but still using the 1970 ratio in step 6 of the table. (This ratio can also be adjusted to approach a value of 1, thus assuming that the local GFR will converge toward the national rate.) The procedures shown in tables H-4, H-5, and H-6 would not be needed as there is no postcensal estimate. If a group of counties is involved, new versions of tables H-10 and H-11 (Section 5, below) would be prepared, but not tables H-12 and H-13.

Having obtained the 1990 projection, an interpolation to obtain the 1984 projection would be carried out by first using the format of table H-8 to obtain data for 1985. The cohort-size adjustment factors for the 1980-90 decade are given in table F-2. To obtain a projection for 1984, or any other year within the five-year period, use straight-line interpolation, age by age.

5. Procedure for Using a Control Total for "Tri-county Area, USA" to Revise Preliminary County Projections of Net Migration for a Postcensal Estimate.

5.1 Introduction. This section demonstrates techniques for revising the preliminary projections of net migration for each county by race and sex to take account of a postcensal estimate, and to adjust the projections so as to agree with a separate computation for the three-county area as a whole. The need for these techniques arises whenever projections are prepared for a group of local areas. The problem of agreement with the area total can, of course, be resolved by letting the sum of the parts serve as the total for the area. This ignores the basic premise that the smaller the area, the greater the possibility of error; when projecting rates of net migration this clearly results in error, because net migration for the sum of the parts will differ systematically from that calculated for the area as a whole (unless all subareas have identical rates).

The illustration presented here is for three U.S. counties, which together make up an SMSA. The actual names are not given, as the intent is to demonstrate a technique generally applicable to U.S. counties or groups of counties. The urban-rural characteristics of the three counties are not unusual for U.S. metropolitan areas in that one county, here called "Central County, USA", contains the entire central city, plus some suburban development. In 1970, it was 82 percent urban. The next largest county had rapid suburban growth from 1960 to 1970, and at the end of the decade was 46 percent urban; it is designated here as "Suburban County, USA". The third county was only 12 percent urban in 1970, but since 1970 it has had rapid population growth, and is called "Exurban County, USA" in this example. Together the three counties form the SMSA, "Tri-county Area, USA".

The basic plan of this Section is to adjust the net migration for the individual counties so as to obtain agreement with the area total. Several stages are required because of (1) the initial lack of agreement of the sum of the parts to the whole; (2) the estimation by race and sex of the postcensal estimate (not available in this detail); and (3) the two-dimensional character of the adjustment, that is, the aggregation of the county values for each race-sex cell (a) to the all classes total of each county, and (b) to the independent area total for each race-sex group. In this example, a two-way raking process is carried out which achieves substantial agreement between these two dimensions, at which point the sum of the parts is accepted.

5.2 Summary of projection data for "Tri-county Area, USA" (Table H-10). The preliminary calculations of the components of change by race and sex for each county are assembled in table H-10 to evaluate the projections and to obtain the totals needed to begin the adjustments. The data in the table show the results of calculations (not shown in the guide) exactly parallel to the calculations presented in tables H-1 to H-6, except that lines 4a to

Table H-10. Summary of Preliminary Projections of Components of Change, "Tri-county Area, USA": July 1, 1970 to 1980

Area, race, and sex	Population July 1, 1970	Components of change, 1970-80			Population July 1, 1980
		Births	Deaths	Preliminary net migration	
	(1)	(2)	(3)	(4)	(5)
1. "Central County, USA".............	248,596	50,795	19,151	-10,942	269,298
a. White males....................	89,590	17,356	6,545	4,994	105,395
b. White females..................	79,708	16,383	5,257	-342	90,492
c. Black males[1]..................	37,872	8,666	3,903	-7,794	34,841
d. Black females[1]................	41,426	8,390	3,446	-7,800	38,570
2. "Suburban County, USA"............	56,682	14,674	3,690	25,910	93,576
a. White males....................	19,625	6,074	1,271	14,356	38,784
b. White females..................	19,940	5,734	840	15,781	40,615
c. Black males[1]..................	8,231	1,456	874	-2,076	6,737
d. Black females[1]................	8,886	1,410	705	-2,151	7,440
3. "Exurban County, USA".............	32,499	7,173	2,675	8,108	45,105
a. White males....................	10,388	2,713	858	4,928	17,171
b. White females..................	10,613	2,561	671	5,139	17,642
c. Black males[1]..................	5,497	965	624	-1,020	4,818
d. Black females[1]................	6,001	934	522	-939	5,474
4. "Tri-county Area, USA" (sum)[2]......	337,777	72,642	25,516	23,076	407,979
a. White males....................	119,603	26,143	8,674	24,278	161,350
b. White females..................	110,261	24,678	6,768	20,578	148,749
c. Black males[1]..................	51,600	11,087	5,401	-10,890	46,396
d. Black females[1]................	56,313	10,734	4,673	-10,890	51,484
5. "Tri-county Area, USA" (control)[3]..	337,777	71,322	25,494	10,150	393,755
a. White males....................	119,605	25,500	8,662	19,258	155,701
b. White females..................	110,258	24,071	6,756	12,842	140,415
c. Black males[1]..................	51,600	11,052	5,403	-11,005	46,244
d. Black females[1]................	56,314	10,699	4,673	-10,945	51,395

[1]Includes, in addition to the Black population, all races other than White.
[2](Sum) indicates that the values represent the sum of the data for individual counties.
[3](Control) indicates that the data are based on an independent control computation for the area total.

4d, representing the entire area, are the sums of the values for the separate counties.[12] This set of numbers is identified as the area "sum," to indicate the manner in which it was obtained, by contrast to lines 5a to 5d, which are the results of an independent calculation for the area control total, identified as the area "control." The two sets show very close agreement as to deaths (not surprisingly, since a single schedule of mortality rates was used) and fairly close agreement on births, even though each county had a different general fertility rate. For net migration, however, there are substantial differences between the two sets, especially for the White population.

The tables which follow illustrate a method of adjusting the individual net migration cells so as to agree with the area total (table H-11), and revising this adjusted net migration for the postcensal estimate (table H-12), and finally, distributing the revised net migration (all classes) by race and sex (table H-13).

5.3 Adjustment of preliminary net migration for counties to area control (Table H-11). As a first step, all of the net migration cells are adjusted to

[12]See Section 3.53 above for the derivation of the components of change in the course of the instructions for table H-9.

Table H-11. Adjustment of Preliminary Net Migration for Counties to Area Control, "Tri-county Area, USA": July 1, 1970 to 1980

Procedural step and area	All classes[1] (1)	Race and sex			
		White male (2)	White female (3)	Black male[2] (4)	Black female[2] (5)
1. Preliminary net migration					
a. "Central County, USA"............	-10,942	4,994	-342	-7,794	-7,800
b. "Suburban County, USA"...........	25,910	14,356	15,781	-2,076	-2,151
c. "Exurban County, USA"............	8,108	4,928	5,139	-1,020	-939
d. "Tri-county Area, USA" (sum)......	23,076	24,278	20,578	-10,890	-10,890
e. "Tri-county Area, USA" (control)..	10,150	19,258	12,842	-11,005	-10,945
2. Adjustment factor (2)=(1e)÷(1d)....	(X)	.7932	[3](+).6362 (-)1.3638	1.0106	1.0051
3. Adjusted net migration (3)=(1)x(2).					
a. "Central County, USA"............	-12,222	3,961	-466	-7,877	-7,840
b. "Suburban County, USA"...........	17,167	11,387	10,040	-2,098	-2,162
c. "Exurban County, USA"............	5,203	3,909	3,269	-1,031	-944
d. "Tri-county Area, USA" (control)..	10,148	19,257	12,843	-11,006	-10,946

X Not applicable.
[1]Represents the sum of race-sex values.
[2]Includes, in addition to the Black population, all races other than White.
[3]Obtained by a "plus-minus" procedure to adjust to the area control. Two factors are computed from the data in column 3, step 1--one specific to positive values and one specific to negative values. The computation of these factors for White females (column 3) is as follows:

Amount of adjustment (a)=(1e)-(1d)	Absolute sum (b)=Σ_a^c line 1	General factor (c)=(a)÷(b)	Specific factors	
			for positive numbers (d)=1+(c)	for negative numbers (e)=1-(c)
-7,736	21,262	-.3638	.6362	1.3638

remove the difference between the two computations for "Tri-county Area, USA" ("sum" and "control"). This adjustment is carried out separately for each race-sex group.

Step 1. Rearrange all of the net migration values in column 4 of table H-11 and enter here horizontally, including the computations for the area sum and control.

Step 2. Calculate an adjustment factor for each race-sex group by dividing the area control by the area sum. The factors so obtained, when multiplied by preliminary net migration, will give values for each cell which sum to the control total for each group. These factors are entered on line 2.

The distribution for White females requires a special adjustment, because there are cells of opposite sign. The "plus-minus" procedure is used here, whereby the amount of the adjustment is distributed according to the amount of net migration in each cell, **without regard to sign**, with all adjustments being in the same direction.[13] One way of calculating the necessary factors is shown in footnote 3. After determining the amount of adjustment required (-7,736), this figure is divided by the absolute sum (21,262), to obtain a general adjustment factor of -.3638. (The "absolute" sum is the sum without regard to sign.) To obtain the factor to use for the positive values in the distribution, this factor is added to 1, giving .6362. The factor for negative numbers is obtained by subtracting the general factor from 1, yielding 1.3638. These factors are multiplied by the appropriate values in step 1, obtaining the adjusted data which now agree with the area control (or very nearly) by race and sex. The differences are due to individual rounding, and in case of a discrepancy, the adjusted data are accepted. The whole distribution now sums to 10,148, as compared with 10,150 for the original control.

5.4 Revision of preliminary net migration for postcensal estimate (Table H-12). In this table, preliminary net migration for each county, as adjusted in table H-11, is **revised** to take account of the postcensal estimate but at the all classes level only. The postcensal estimate prepared through the Federal-State Cooperative Program is published for all classes only. If the estimate were available by race, the computation shown here would be done separately for each race. The general procedure is to compute average annual rates of net migration (1) for the projection period 1970-80, and (2) for the postcensal estimate period, in this case 1970-74. Weights are assigned to each rate (in this case equal weight), and the weighted average is assumed to continue for the period 1974-80. This net migration is added to that estimated for 1970-74 to give the revised figure for the decade. The revised projection thus departs from the 1974 estimate as a base date, even though the ten-year period 1970-80 is retained as the basic projection-period unit.

Steps 1-4. Enter the basic data already developed in the projections as indicated. The sources are noted in the table.

Step 5. Compute the annual average net migration ratio for the period 1970-80 in accord with the formula shown. (The word "ratio" is used here, because the value shown is the rate of net migration plus 1.) The computation gives an annual average ratio, which multiplied by itself 10 times would equal the original 10-year ratio. The 10th root required by the formula can be calculated with logarithms if calculators with this capability are not available.

Step 6. This step repeats the technique of the preceding step but for the postcensal estimate period. The resulting ratios at this step must be critically compared with those indicated by the preliminary projection in step 5. For "Central County, USA" the two ratios are similar, but for the other two counties the new estimated trend differs sharply from that projected. For "Suburban County, USA", the estimate is much below the projected trend, with the opposite for the remaining county. How should the revised projection resolve these conflicting trends?

If in the judgment of the analyst the new trend indicated by the estimate appears to be solidly based, it would be reasonable to assume it would continue. However, there may be special conditions which have exerted an influence on population growth. Some of these are discussed in Section 2.3 of this guide. The quality of the data used in preparing the estimate should also be considered. After a review of the situation, weights can be assigned to the trends, or, if an independently derived projection of net migration is available for the period

[13] See Section 3.31 of this appendix for a discussion of the "plus-minus" technique.

Table H-12. Revision of Preliminary Net Migration for Postcensal Estimate, "Tri-county Area, USA": July 1, 1970 to 1980

Procedural step (Dates as of July 1)	"Tri-county Area, USA" (1)	"Central County, USA" (2)	"Suburban County, USA" (3)	"Exurban County, USA" (4)
1. Population, 1970	337,777	248,596	56,682	32,499
2. Estimated population, 1974	362,000	259,900	60,400	41,700
3. Preliminary net migration, 1970-80	10,150	-12,222	17,167	5,203
4. Estimated net migration, 1970-74	6,118	-1,224	376	6,965
5. Average annual net migration ratio, 1970-80.. $(5) = \sqrt[10]{[(3) + (1)] \div (1)}$	[1]1.002965	.994971	1.026809	1.014961
6. Average annual net migration ratio, 1970-74. $(6) = \sqrt[4]{[(4) + (1)] \div (1)}$	[1]1.004498	.998767	1.001654	1.049742
7. Weighted average annual net migration ratio.. $(7) = .5\,[(5) + (6)]$	[1]1.003732	.996869	1.014232	1.032352
8. Weighted net migration ratio, 1974-80 $(8) = (7)^6$	1.022602	.981361	1.088489	1.210506
9. Revised net migration, 1974-80 $(9) = [(8) \times (2)] - (2)$	[1]8,182	-4,844	5,345	8,778
10. Revised net migration, adjusted to area control, 1974-80. (10)=(9) x specific factor[2]	8,182	-5,124	5,036	8,271
11. Revised net migration, 1970-80 (11) = (4) + (10)	14,300	-6,348	5,412	15,236

[1]Area calculation is independent of county calculations.
[2]See footnote 3, table H-11 for description of "plus-minus" procedure. The computation is as follows:

Step 9, Algebraic sum	Step 9, Revised net migration	Amount of adjustment	Absolute sum	General factor	Specific factors-- for positive numbers	Specific factors-- for negative numbers
$(a)=\Sigma_2^4$ step 9	(b)=col. 1, step 9	(c)=(b)-(a)	$(d)=\Sigma_2^4$ step 9	(e)=(c)-(d)	(f)=1+(e)	(g)=1-(e)
9,279	8,182	-1,097	18,967	-.0578	.9423	1.0578

Sources:

Line 1. The sum of the computations for all race-sex groups producing column 1 of table H-2, (computations not shown).

Line 2. Federal-State Cooperative Program estimates published in Current Population Reports, Series P-26, U.S. Bureau of the Census.

Line 3. Column 1, Step 3 of table H-11.

Line 4. The estimated net migration figures for the 4-year period given here were obtained by taking 16/17's (.941176) of the net migration for the $4\frac{1}{4}$-year period April 1, 1970 to July 1, 1974 given in Current Population Reports, Series P-26.

1974-80, it would be entered at step 9. See also Section 3.3, step 7 of this appendix for a similar discussion regarding projections for a single county.

Step 7. For purposes of this illustration, equal weight has been assigned to the two trends. A general rationale for this decision is that the original projected trend, which reflects the change indicated by the censuses of 1960 and 1970, should be assigned more weight as the data are based on censuses, and represent a longer period of experience. On the other hand, the estimated trend for 1970-74 is more recent. Assigning equal weight seems reasonable in the absence of other information. However, as mentioned above, there is some doubt as to future migration for the two outlying counties. One feels more comfortable about the assumption of equal weight for the area total, and for "Central County, USA", because the estimate is more in line with the trends of the past.

Step 8. Convert the annual ratios in step 7 to ratios for the 6-year period 1974-80 by raising them to the sixth power.

Step 9. Multiply the base population in 1974 by the ratio in step 8 to obtain revised net migration for the 6-year period. However, the sum of the county figures does not agree with the area total, as the latter is the result of a separate computation.

Step 10. The imbalance is resolved by a "plus-minus" adjustment. This procedure is shown in table H-11. The computation of the factors to be used here are shown in footnote 2 of that table.

Step 11. Add the adjusted net migration for 1974-80 to that estimated for 1970-74 to give a revised projection for the period 1970-80.

5.5 Adjustment by race and sex to revised total net migration (Table H-13). The revised net migration obtained in table H-12 must be distributed first by race and sex to prepare for a later adjustment of the age detail. The totals for each sex can usually be adjusted satisfactorily by a simple mathematical procedure, as in general, net migration is distributed about evenly between the two sexes.[14] A simple mathematical adjustment by race is much more problematical, as shifts in migration trends like those encountered in the two outlying counties of "Tri-county Area, USA" may very well be race-specific. In these counties, for example, the shifts may all be caused by a change in the pattern of White rates, with no change in the migration rates for Blacks. Nonetheless, mathematical techniques which can be used in any situation are demonstrated here.

The general procedure in table H-13 is to adjust the preliminary projections of net migration by race and sex, which summed to a total of 10,150, so as to agree with the revised area figure of 14,300 obtained in table H-12 (step 11, col. 1).

Step 1. Enter the preliminary net migration (step 1, table H-11). The individual cells sum to the totals entered in column 1. The procedure will be to adjust these data by successive approximations so as to sum to the revised county totals in column 6, while still agreeing with the race-sex totals for the area. The first step is to remove the small difference between the two figures for the total area (14,300, revised, and 10,150, preliminary).

Step 2. The adjustment is based on population, and a factor is calculated which, when multiplied by the 1970 population for each cell (shown in table H-10) produces an adjustment to net migration which will increase the preliminary figure so as to sum to the revised figure. The calculation of this factor is explained in footnote 4.

Step 3. Add the adjustments to net migration in step 2 to the original distribution in step 1.

Step 4. As a second approximation, the data in step 3 are adjusted so as to agree with each county's total revised net migration. A "plus-minus" procedure is used which is carried out horizontally, line by line. The computation of the adjustment factors is shown in footnote 5. The data now agree with the revised totals for each county developed in table H-12, but the sum of the county cells for each race-sex group does not agree with the computation for the "control," which was carried out separately. The "sum" is shown at step 1d, and the "control" at 1e.

Note that the adjustment factors for both of the non-central counties are large, and that as a result the migration projections for both the Black and White populations are substantially altered. In this particular case, the change in trend is believed to be primarily for the White population, but the plus-minus procedure automatically assigns part of the change to Blacks. This result underscores the potential value of a postcensal estimate specific by race.

Step 5. One more approximation is done to bring the net migration cells into agreement with the area control for each race-sex group (vertically in this

[14] The imbalance in "Central County, USA" is due to the presence of military bases.

Table H-13. Adjustment by Race and Sex to Revised Total Net Migration for Counties, "Tri-county Area, USA": July 1, 1970 to 1980

Procedural step and area	All classes[1] (preliminary) (1)	Race and sex: White male (2)	White female (3)	Black male[2] (4)	Black female[2] (5)	All classes[3] (revised) (6)
1. Preliminary net migration						
a. "Central County, USA"	-10,942	4,994	-342	-7,794	-7,800	(-6,348)
b. "Suburban County, USA"	25,910	14,356	15,781	-2,076	-2,151	(5,412)
c. "Exurban County, USA"	8,108	4,928	5,139	-1,020	-939	(15,236)
d. "Tri-county Area, USA" (control)	10,150	19,258	12,842	-11,005	-10,945	(14,300)
2. Adjustment[4]						
a. "Central County, USA"	3,054	1,101	979	465	509	(X)
b. "Suburban County, USA"	696	241	245	101	109	(X)
c. "Exurban County, USA"	400	128	130	68	74	(X)
d. "Tri-county Area, USA" (control)	4,150	1,469	1,355	634	692	(X)
3. Preliminary net migration adjusted to area control						
a. "Central County, USA"	-7,888	6,095	637	-7,329	-7,291	(X)
b. "Suburban County, USA"	26,606	14,597	16,026	-1,975	-2,042	(X)
c. "Exurban County, USA"	8,508	5,056	5,269	-952	-865	(X)
d. "Tri-county Area, USA" (control)	14,300	20,727	14,197	-10,371	-10,253	(X)
4. Net migration, adjusted to county[5]						
a. "Central County, USA"	-6,347	6,535	683	-6,800	-6,765	(X)
b. "Suburban County, USA"	5,413	5,666	6,221	-3,183	-3,291	(X)
c. "Exurban County, USA"	15,237	7,858	8,189	-424	-386	(X)
d. "Tri-county Area, USA" (sum)	14,303	20,059	15,093	-10,407	-10,442	(X)
e. "Tri-county Area, USA" (control)	14,300	20,727	14,197	-10,371	-10,253	(X)
5. Net migration, adjusted by race-sex[6]						
a. "Central County, USA"	-6,024	6,753	642	-6,776	-6,643	(X)
b. "Suburban County, USA"	5,304	5,855	5,852	-3,172	-3,231	(X)
c. "Exurban County, USA"	15,021	8,120	7,703	-423	-379	(X)
d. "Tri-county Area, USA" (sum)	14,301	20,728	14,197	-10,371	-10,253	(X)

X Not applicable.

Source: Step 1. Table H-11, step 1.

[1]Sum of individual race-sex groups.
[2]Includes, in addition to the Black population, all races other than White.
[3]Revised net migration, computed in table H-12.
[4]Adjustment factor applied to 1970 population = .012286. Computed by subtracting the sum of the race-sex groups preliminary net migration (step 1d, col. 1) from the revised net migration for the area control (step 1, col. 6) and dividing by the total population of the entire area (table H-10, line 4) [(14,300 - 10,150)÷337,777= .012286].
[5]Obtained by a "plus-minus" adjustment (horizontally) to agree with each county's total net migration. Two factors are computed from step 3, one specific to positive values for net migration, and the other specific to negative values. The computation of these factors is shown below for each county:

County	Amount of adjustment (a)=(col. 6, step 1) - (col. 1, step 3)	Absolute sum (b)=Σ|| in step 3	General factor (c)=(a)÷(b)	Specific factors-- for positive numbers (d)=1+(c)	for negative numbers (e)=1-(c)
a. "Central"	1,540	21,352	.072124	1.072124	.927876
b. "Suburban"	-21,194	34,640	-.611836	.388164	1.611836
c. "Exurban"	6,728	12,142	.554110	1.554110	.445890

[6]Obtained by a pro rata adjustment (vertically) to bring the sum of the county figures for each race-sex group into agreement with the "control" (line 4e). The adjustment factors (obtained by dividing line 4c by line 4d) are: White male, 1.033302; White female, .940635; Black male, .996541; and Black female, .981900. In this example, net migration has the same sign for each county within a race-sex group. If there were contrasting signs (as will occur frequently), a plus-minus adjustment would be needed, as in footnote 5.

Table H-14. Summary of Revised Projections of Components of Change, "Tri-county Area, USA": July 1, 1970 to 1980

Area, race, and sex	Population July 1, 1970 (1)	Components of change, 1970-80: Births (2)	Deaths (3)	Revised net migration (4)	Population July 1, 1980 (5)
1. "Central County, USA"................	248,596	51,516	19,170	-6,024	274,918
a. White males........................	89,590	17,483	6,548	6,753	107,278
b. White females......................	79,708	16,606	5,261	642	91,695
c. Black males[1].......................	37,872	8,855	3,910	-6,776	36,041
d. Black females[1].....................	41,426	8,572	3,451	-6,643	39,904
2. "Suburban County, USA"...............	56,682	12,013	3,634	5,304	70,365
a. White males........................	19,625	4,887	1,246	5,855	29,121
b. White females......................	19,940	4,614	822	5,852	29,584
c. Black males[1].......................	8,231	1,277	867	-3,172	5,469
d. Black females[1].....................	8,886	1,235	699	-3,231	6,191
3. "Exurban County, USA"................	32,499	7,969	2,692	15,021	52,797
a. White males........................	10,388	3,029	865	8,120	20,672
b. White females......................	10,613	2,861	675	7,703	20,502
c. Black males[1].......................	5,497	1,057	627	-423	5,504
d. Black females[1].....................	6,001	1,022	525	-379	6,119
4. "Tri-county Area, USA" ("Control")[2]...	337,777	71,498	25,499	14,301	398,077
a. White males........................	119,605	25,399	8,660	20,728	157,072
b. White females......................	110,259	24,081	6,757	14,197	141,780
c. Black males[1].......................	51,600	11,189	5,407	-10,371	47,011
d. Black females[1].....................	56,313	10,829	4,675	-10,253	52,214

[1]Includes, in addition to the Black population, all races other than White.
[2]"Control" indicates that the data are based on an independent control computation for the area total. Data may differ from the sum of county data due to independent rounding.

table). The computation of the required factors by a pro-rata adjustment is shown in footnote 6. (A plus-minus procedure would have been used if there had been values of contrasting sign.)

This last approximation brings agreement by race and sex, but throws the county totals out of agreement with the original county totals for all ages. This is allowed to stand, as the computation for the area total is deemed more important. If the adjustment were being carried out by computer, steps 4 and 5 could be reiterated until little difference remained between the totals in both dimensions.

This concludes the step-by-step illustration of the adjustment of county net migration to an area control. In order to complete the population projections for each of the counties and for the metropolitan area, computations parallel to tables H-5 and H-6 in this appendix must be prepared. This has been done (computation not shown), and the revised components of change are shown in table H-14. As a result of the adjustment for the postcensal estimate, the revised population projections for the two non-central counties are significantly changed.

It was necessary to recompute births, and the sum of the computations for the individual counties was allowed to stand as the total for the area. If there are significant differences among the counties in the general fertility rate, it would be necessary to adjust the county totals to agree with the independent computation for the area.

Deaths for the individual counties are almost in agreement. The population by age (not shown), for each race-sex group, does not sum to the area control because the distribution of adjusted net migrants by age is not controlled for this dimension. If this is considered important, a multiple raking procedure similar to that described in this appendix can be carried out.

GLOSSARY

(The definitions are in general terms suited for non-technical use, and relate primarily to population estimates and projections. For more precise expressions, refer to the United Nations Multilingual Demographic Dictionary, and Kendall and Buckland, Dictionary of Statistical Terms. Page numbers in parentheses indicate a further discussion in the text. An asterisk (*) indicates that the glossary includes a definition of the word marked)

age-specific fertility rate—the number of children born during a year to women of a specified age group, divided by the midyear population of the group. Usually expressed per 1,000 population. See **birth rate** and **general fertility rate.**

birth rate, or crude birth rate—the number of births in a year divided by the midyear total population. Usually expressed per 1,000 population.

child-woman ratio—the ratio of the number of children (usually 0-4 years of age) to women of childbearing age (usually 15 to 44 years of age).

cohort, or birth cohort—a group of persons born in a specified year or period. Demographic analysis traces statistics for a cohort through time. For example, the survivors of a cohort born April 1, 1950 to April 1, 1955 are 5 to 9 years of age on April 1, 1960, and 15 to 19 years of age on April 1, 1970.

cohort-component method—a method of carrying forward the population by age (and if desired, by sex and race) and by component* (births, deaths and migration*), maintaining cohort* identity.

cohort fertility—an analytical concept in the study of fertility*, whereby birth data are arranged by birth cohort* of mother and analyzed over time with respect to some demographic characteristic.

component—the components of population change are births, deaths, and migration*.

confidence interval—the limits around a sample estimate, within which the true value may be expected to lie, with a stated degree of confidence.

death rate, or crude death rate—the number of deaths in a year divided by the midyear total population. Usually expressed per 1,000 population.

demography—the scientific study of human populations, primarily with respect to size, structure, geographic distribution, and change.

"demographic" projections—population projections obtained by working with the demographic components* of population change (births, deaths, and migration*), as opposed to projections which take economic or other factors into account.

emigrants—migrants from a country to other countries.

estimate—a population figure representing some date in the past arrived at by carrying forward the immediately preceding census count using statistics for elements related to population change.

extrapolation—the estimation of a value by extending a trend observed between two or more data points outside the range defined by the points. See **interpolation**.

fertility—the contribution of childbearing to population change. Fertility statistics and studies often emphasize the characteristics of women of childbearing age.

forecast—a type of projection* which represents a judgment about probable future change rather than merely the consequences of a set of hypothetical assumptions. (See p. 3.)

forward survival—a technique used in cohort-component* models whereby the population at time t is carried forward by cohort* to time t + n years, by adjusting for change in cohort size.

general fertility rate—the number of births in a year divided by the midyear number of women of childbearing age (usually 15 to 44 years of age). Generally expressed per 1,000 population.

geometric rate of change—change expressed as a rate per unit of time. Sequential repetition of the rate produces a geometrically changing series.

Gompertz curve—a mathematical curve which describes population growth as a function of time, where the relative growth rate declines at a constant rate.

grade progression ratio—the ratio of students enrolled in a specified grade range at one date to the number enrolled one year earlier in the range one year younger. (The time interval and grade interval varies.)

gross migration—data which identify separately out- and in-migrants* for each geographical unit.

immigrants—migrants to a country from other countries.

in-migration—the migration* of population **into** a geographical unit.

interpolation—the estimation of an intermediate value <u>within</u> the range defined by two data points. See **extrapolation.**

labor force—the employed plus the unemployed population.

labor force participation rate—the proportion of a population in the labor force, usually specific by age and sex.

least squares line—a straight line or curve calculated to fit a series of data such that the sum of the squared deviations of the data points from the line is a minimum.

life table—a table representing the mortality* experience of a stated population, showing the probability of death at each age, the number of survivors to each age of an assumed number of births, and other related statistical measures.

life table survival rates—rates calculated from the L_x column of a life table, representing the probability of survival of a cohort* from one age group to another.

logistic curve—a mathematical curve which describes population growth as a function of time, where the growth rate first increases, then decreases as the series progresses.

market area, or labor market area—a geographic unit large enough for all or nearly all of the persons employed in the area to reside in the area.

micro-simulation models—computer-oriented models of population processes, which carry one person at a time through a series of events approximating real life situations, by assigning probabilities to the occurrence of each event. (See p. 29.)

migration—a permanent change of residence from one geographical unit to another.

mortality—the contribution of death to population change.

national census survival rates (NCSR)—survival rates* calculated from two successive national censuses. (See p. 18, Section 3.233)

natural increase—the net contribution of births and deaths to population change.

net census undercount—the net balance of errors in census counts for age groups due to the combined effect of failure to enumerate all persons, and misreporting of age. (See Section 2.36)

net migration—the net balance of in- and out-migration* for a geographical unit.

out-migration—the migration* of population **out** of a geographical unit.

participation rate—a rate representing the proportion of the population "participating" in a given activity, often specific to an age group, e.g., labor force participation rate*.

place-to-place migration—migration* statistics identifying separately the origin and destination of migrants.

plus-minus adjustment—a technique whereby a set of numbers with both positive and negative values is adjusted so as to sum to a new, predetermined total. (See p. 77.)

postcensal population estimate—an estimate for a date subsequent to the most recent census. Distinct from an intercensal estimate, which is for a date between two censuses, taking both censuses into account.

prediction—an unequivocal statement about a future value.

projection—a figure for a future date obtained by carrying forward assumed trends, without modification of the projected numbers once the assumptions are defined and established.

regression technique—in population projections, a method of extending trends into the future, using an equation which expresses mathematically the relationship between population growth and various data indicative of population growth for a past period. (See p.12 .)

residual method of estimating net migration—the calculation of net migration* from two census counts as the difference between total change and natural increase*.

station strength—the number of military personnel permanently assigned for duty at a military installation.

straight-line interpolation—calculation of intermediate points which, on a graph, would fall on a straight line drawn between two points.

survival rate—a rate which represents the proportion of the population of a specified age surviving for a specified period of time.

underenumeration—the failure to enumerate members of a population in a census or survey, as distinct from net census undercount*, which includes the effect of misreporting of characteristics, particularly age.

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